No. 3081.

UNITED STATES CIRCUIT COURT OF APPEALS

FOR THE NINTH CIRCUIT.

MINERALS SEPARATION, Ltd., et al.,
Appellees,

vs.

BUTTE & SUPERIOR MINING COMPANY,
Appellant.

PLAINTIFFS' LIMITATIONS REGARDING THE AGITATION FROTH PATENT 835,120.

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PATENT IN SUIT.

The Patent in Suit, No. 835,120.

(T. R., Vol. III, page 951):

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite, and the like, from gangue by means of oils, fatty acids, or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the previous United States patent No. 777,273, granted to A. E. Cattermole, an amount of oil varying from four per cent. to six per cent. of the weight of metalliferous matter present is agitated with an ore pulp, so as to form granules which can be separated from the gangue. (Lines 9-22.)

We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent. on the ore—granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum. This tendency is dependent on a number of factors. Thus the water in which the oiling is effected is preferably slightly acidified by adding, say, a fraction of one per cent. up to one per cent. of sulfuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or, in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and

the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present. Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed. The formation of froth is assisted by the fine pulverization of the ore, and we find that slime mineral most readily generates scum and rises to the surface, while larger particles have less tendency to be included in the froth. The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances. . . . (Lines 28-64.)

The following is an example of the application of this invention to the concentration of a particular ore. An ore containing ferruginous blende, galena, and gangue consisting of quartz, rhodonite, and garnet is finely powdered and mixed with water containing a fraction of one per cent. or up to one per cent. of a mineral acid or acid salt, conveniently sulfuric acid or mine or other waters containing ferric sulfate. To this is added a very small proportion of oleic acid (say from 0.02 per cent. to 0.5 per cent. on the weight of ore). (Lines 70-82.)

The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical. (Lines 96-101.)

(Page 953):

1. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore),

agitating the mixture until the oil-coated mineral matter forms into a froth, and separating the froth from the remainder by flotation.

2. The herein-described process of concentrating ores which consists in mixing the powdered ore with slightly acidified water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), agitating the mixture until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

3. The herein-described process of concentrating ores which consists in mixing the powdered ore with slightly-acidified water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), warming the mixture, agitating the mixture until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

5. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of oleic acid amounting to 0.02-0.5 per cent. on the ore, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

6. The herein-described process of concentrating ores which consists in mixing the powdered ore with water containing a fraction of one per cent. of sulfuric acid, adding a small proportion of oleic acid amounting to 0.02-0.5 per cent. on the ore, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

7. The herein-described process of concentrating ores which consists in mixing the powdered ore with water containing a fraction of one per cent. of sulfuric acid, adding a small proportion of oleic acid amounting to 0.02-0.5 per cent. on the ore, warming the mixture to 30°-40° Centigrade, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

9. The process of concentrating powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, agitating the mixture to form a froth, and separating the froth.

10. The process of concentrating powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, warming the mixture, agitating the mixture to form a froth, and separating the froth.

11. The process of concentrating powdered ores, which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil and a quantity of acid insufficient to cause chemical action on the metalliferous minerals present, agitating the mixture to form a froth, and separating the froth.

12. The process of concentrating powdered ore which consists in separating the minerals from gangue by coating the minerals with oil in water containing a fraction of one per cent. of oil on the ore, agitating the mixture to cause the oil-coated mineral to form a froth, and separating the froth from the remainder of the mixture.

Disclaimer.

(T. R., Vol. 1, pages cxv-cxvii):

UNITED STATES PATENT OFFICE.

Hon. Commissioner of Patents,

Sir:

Your Petitioner, Minerals Separation, Limited, a corporation organized and existing under the laws of Great Britain and having its principal place of business in London, England, hereby represents as follows:

1. That on November 6th, 1906, letters patent of the United States for Ore Concentration, No. 835,120, were granted to Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot, of London, England, and your petitioner is now the sole and exclusive owner of the said letters patent.

2. That by the decision of the Supreme Court of the United States in *Minerals Separation, Limited, and Minerals Separation, American Syndicate, Limited,* v. *James M. Hyde,* filed the 11th day of December, 1916, your petitioner is advised that the said letters patent No. 835,120, in so far as concerns claims 9, 10 and 11 thereof, covers and includes more than the said inventors had a right to claim as new.

3. That the matter which the said patentees and your petitioners are, in accordance with the said decision of the said court, not entitled to hold or claim by virtue of said claims 9, 10 and 11 of said letters patent No. 835,120 was included therein by mistake, and without fraudulent or deceptive intent, and without any wilful default or intent to defraud or mislead the public.

4. That the subject-matter not herein and hereby disclaimed is definitely distinguishable from the part

or parts disclaimed herein, and is truly and justly the invention of the said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot, and is a material and substantial part of the thing patented.

Your petitioner, therefore, for the purpose of complying with the requirements of the law in such case made and provided, and of disclaiming those parts of the thing patented which your petitioner does not choose to claim or hold by virtue of said letters patent No. 835,120, does hereby disclaim from claims 9, 10 and 11 of said letters patent No. 835,120, any process of concentrating powdered ores excepting where the results obtained are the results obtained by the use of oil in a quantity amounting to a fraction of one per cent. on the ore.

In witness whereof your petitioner has caused these presents to be signed and sealed by John Ballot, its duly constituted attorney in fact under and by virtue of a power of attorney dated December 14, 1915, and recorded in the United States Patent Office November 27, 1916, in Liber K 101, page 176 of Transfers of Patents, this 27th day of March, 1917.

MINERALS SEPARATION, LIMITED,
By JOHN BALLOT (L. S.),
Attorney in Fact.

In presence of
S. GREGORY,
HENRY D. WILLIAMS.

State of New York, County of New York, ss.

On this 27th day of March, 1917, before me personally came John Ballot, attorney in fact of Minerals Separation, Limited, a company organized under the laws of Great Britian, to me personally known, and

known to me to be the individual described in and who, as such attorney, executed the within petition and acknowledged that he executed the same as the act and deed of Minerals Separation, Limited, therein described, by virtue of a power of attorney duly executed by said Minerals Separation, Limited, bearing date December 14, 1915, which power of attorney was exhibited to me, and he stated that it was still in force and effect.

(Seal) HARRY C. LEWIS,
Notary Public, Bronx Co., No. 12.
Certificate filed in New York County, No. 41.

File-Wrapper and Contents of Patent in Suit, No. 835,120.

(Vol. IV, page 1974):

The following claim was presented in amendment received by the Patent Office April 18, 1906 (See Vol. IV, page 1996):

> "12. The process of concentrating powdered ore, which consists in separating the minerals from gangue by coating the minerals with oil in water containing a fraction of 1% of oil on the ore, and recovering the oil coated minerals."

This claim was rejected by the Examiners of the Patent Office in charge of this application under date of June 18, 1906, as follows:

(Page 2004):

Case as amended June 15, 1906, further considered.

Claim 12 is rejected in view of 763,260, Cattermole, June 21, 1904; or 793,808, Sulman *et al.*, July 4, 1905, Washers (H), as expressing merely a difference of degree thereover as to the proportion of oily matter employed.

LEWIS B. WYNNE,
Examiner,
Div. XXV.

T. F. MITCHELL.

THE AGITATION FROTH PATENT.

CHARACTERISTICS BY WHICH THE INVENTION MAY BE IDENTIFIED, AND THE LIMITS THEREOF.

COMPLAINANTS' PROOFS.

Edward H. Nutter.

(T. R., Vol. II, pages 50-51):

40 X-Q. Please describe the steps constituting this process which you term the "agitation froth process."

A. You mean the steps necessary in using this process, I assume. The steps are not always the same nor always taken in the same order on all ores. In the application of the agitation froth process to such an ore as that of the Butte & Superior Copper Company, the steps would consist of agitating an ore pulp consisting of finely ground or comminuted ore mixed with water, which had been acidulated with sulphuric acid and to which had been added a small quantity less than one per cent., of what we usually term an oily re-agent, of which oleic acid is an example. This mixture is agitated with considerable vigor so that, when the agitated pulp is allowed to flow into a separating chamber or spitzkasten, the sulphide mineral contained in the ore rises to the surface of the water in the separating chamber as a froth, which is or can be flowed off and collected and which forms the valuable concentrate. These steps are repeated until the required extraction of the valuable ore constituents from the ore pulp has been obtained, when the tailings are allowed to go to waste, or, if desired for reasons of economy, they are first dewatered. All of these steps form a continuous treatment of the ore pulp as it flows through the apparatus.

(Page 61):

69 X-Q. About what quantity of oily matter or oleic acid relative to the weight of the ore have you seen used in the application of the process which you have called the Minerals Separation process?

A. The quantity used varies with different ores, and with different oily re-agents. Usually a few pounds of oily re-agent at the outside, per ton of ore, is sufficient to give the desired results.

70 X-Q. What are the maximum and minimum limits which you intend to indicate by the expression "a few pounds of oily reagent" per ton of ore?

A. Good results on an ore are usually obtainable with less than ten pounds of oily re-agent, per ton of ore.

(Pages 68-69):

99 X-Q. In froth flotation processes of the general type referred to by you as the Minerals Separation process, does any unfavorable result occur if a comparatively large amount of oil is used, say a hundred pounds to the ton of ore?

A. My observations have been that when such a quantity of oil as this is used, that the resultant effect ceases to be accurately described as a froth flotation process, as a different set of phenomena are apt to come into play.

100 X-Q. Will you describe these other phenomena which you refer to, which are incident, as you say, to the use of a large amount of oil?

A. I have not seen, except with small scale experiments, any such amount of oil as you describe used. In some small scale tests I have seen, where a quantity considerably in excess of the amount used to produce frothing was tried, though I am not sure nor do I recollect

whether the quantity was such as you indicate, the effect was to gather the valuable mineral of the ore into granules, which remained at the bottom of the vessel in which the experiment was tried.

(Page 71):

106 X-Q. What differences in mode of procedure cause the Cattermole effect of precipitation to be obtained under some circumstances and flotation of the larger part of the concentrate under other circumstances?

A. I really am not qualified to testify on this point, as I have seen so little of the Cattermole process. It is my understanding, however, that the chief difference in the results is brought about by the difference in the quantity of oil used.

(Page 74):

119 X-Q. Then what would you do?

A. I would alter the adjustment of operations step by step until I found a condition wherein these granules were not discharged with the tailings.

120 X-Q. What particular adjustment would you think of altering first?

A. There are several adjustments which might occur to anyone skilled in the art and which would, I think, occur to me. One of them would be to alter the rate of flow of pulp through the plant. Another would be to alter the speed of agitation. Another would be to alter the quantity or kind of oil used on the particular ore being treated. Another might be to alter the dilution of the solution circuit with reference to dissolved salts therein. Another might be to alter the temperature of the solution circuit. Another might be to vary the internal arrangement of baffles or other diverting devices so as to affect the direction of flow of the ore pulp. All

of these adjustments might have some effect or considerable effect, or any of them might have effect upon the formation of the agglomerations which I have described.

(Page 76):

126 X-Q. State some particular case and give us the rule for the correction of the agglomeration and settling effect.

A. In an ore containing zinc sulphide and gangue mineral, in which it was found to be necessary to use for the treatment by flotation thereof to give the best commercial results, a mixture of finely ground ore, water heated above the atmospheric temperature, sulphuric acid and oleic acid, if it should be found that adjustment of the other elements which I have previously described did not produce sufficient diminution of this agglomerating effect, and if it had been found that all or most of the mineral occurring in the ore could be floated as a concentrate froth and was not doing so, I would expect, if the quantity of oleic acid used was in excess of the usual amount found necessary in the treatment of such ores, that a diminution of the quantity of oleic acid would reduce this agglomerating effect, and I would lay down a rule, then, that such quantity be reduced under these conditions.

Dr. Charles F. Chandler.

Complainants' expert witness testified as follows (T. R., Vol. II, pages 137-139):

Before beginning to describe the nature of their invention, the patentees refer to the Cattermole granulation process, in which oily matters were employed in ore concentration in a manner totally different from that of the patent in suit. I cannot do better than quote from the specification, as follows:

> "In the process described in the previous United States patent, No. 777,273, granted to A. E. Cattermole, an amount of oil varying from four per cent. to six per cent. of the weight of metalliferous matter present is agitated with an ore pulp, so as to form granules which can be separated from the gangue. In the previous United States patent, No. 777,274, granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced *in situ* in the ore pulp."

Without going into details I would state that in both these patents so large an amount of oily matter is employed as to agglomerate together the metalliferous matter contained in the ore into granules or pellets of substantial size, but at the same time the amount of oily matter is not sufficient to float the metalliferous matter, but, on the contrary, the pellets, owing to the specific gravity of the metalliferous matter, are so heavy they remain at the bottom of the vessel containing the pulp, even when an up-current of water is employed, while the non-metalliferous matter or gangue, while being considerably heavier than water, are nevertheless carried up through the liquid and discharged over the upper edge of the vessel, the result being a comparatively complete separation of the metalliferous matter, which passes away with the upward current of water.

The patentees then go on to explain the nature of their invention. They make the following statements:

> "We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent. on the ore—granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum."

This discovery is the foundation of the invention described and claimed in this patent. The patentees then go on to describe the peculiarities of the process which they have devised, making the following statement:

> "This tendency is dependent on a number of factors."

(Page 141):

The oily matter which they recommend in this case is oleic acid in very small proportions from 0.02 per cent. to 0.5 per cent. on the weight of the ore; reducing these quantities to pounds of oleic acid per ton of 2,000 pounds of ore, I find that 0.02 per cent. of oleic acid is four-tenths of one pound or less than six and one-half ounces to the ton, while 0.5 per cent. is ten pounds to the ton of ore of oleic acid.

(Page 142). They then state:

> "The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical."

0.1 per cent. of the ore is two pounds of oleic acid to the ton of 2,000 pounds of ore, that being the ton usually employed in the United States.

(Pages 175-176):

27 X-Q. Is it your understanding that, in the treatment of any selected material, such as that in evidence as Feed to Flotation Plant, there is some definite point in the quantity of oil used at which a transition takes place between the effects described in the Cattermole patents referred to in the patent in suit and the effect of flotation for which the process of the patent in suit is described as being useful?

A. I am sure I don't know any exact point of demarcation. Cattermole describes a process in which he used five or six per cent. of oil and so manipulates his material as to cause the metalliferous constituent of the ore to form heavy granules which settle to the bottom, while the non-metalliferous material or gangue is floated off the top or carried off by the current. In the patent in suit, by the use of a fraction of one per cent. of oil and brisk agitation in water, the metalliferous constituent of the ore is floated off at the top as a froth, while the non-metalliferous mineral, the gangue, settles to the bottom. Not only is there an absolute and radical difference in the amount of oil employed, but there is also a radical difference in the mode in which the oil is applied to the ore. There is no object in the Cattermole process of agitating his material so as to produce froth and send his metalliferous mineral to the surface. That is just what he does not want to do. On the other hand, in the patent in suit there is no object in so manipulating materials as to cause the metalliferous material to remain at the bottom. That is just what the patentees do not want to do. So that if either the patentees of the patent in suit or Cattermole so varied their processes that either would produce the results described by the other, he would cease to be carrying out his own process.

(Pages 176-177):

30 X-Q. I invite your attention to the passage extending from line 31 to line 35, page 1 of the patent in suit, in which it is stated that part of the oil-coated metalliferous matter rises to the surface, and ask what becomes of the remainder of the oil-coated metalliferous matter?

A. It remains in the tailings. I have found in all my experiments that I failed to bring to the surface all of the metalliferous mineral; particles of it were left distributed in the gangue, but they were never in the form of granules. They were always as isolated particles, having for some reason failed to be carried to the surface.

(Pages 177-178):

33 X-Q. In lines 64-69, page 1 of the patent in suit, reference is made to a preliminary test to determine which oily substance yields the proportion of froth or scum desired. In your judgment, just what proportion of froth or scum is it desirable to secure in practicing the process of the patent in suit?

A. The object of applying the process of the patent in suit is to separate the valuable metalliferous particles from the worthless gangue particles, and it is desirable to get out the largest possible percentage of the metalliferous particles. The patentees have found evidently from their statement, to which you refer, that working the different ores, one oily substance may be more efficient in accomplishing the desired result with a particular ore than another oily material. If, therefore, one had a new ore to operate upon, he would naturally test that ore with the different oils at his command, using them in varying proportions, until he found which oily material and which proportion gave him the best results, as it would naturally be his desire in each case to secure the best results.

(Pages 180-181):

39 X-Q. In treating an ore containing eight per cent. of zinc in the form of blende and the remainder of the ore consisting of non-metalliferous gangue, what would be the maximum and the minimum amounts of oil per ton of ore to be used according to the directions appearing in lines 72-79, page 2 of Cattermole patent No. 777,273?

A. 9½ lbs. is the minimum and 14¼ lbs. is the maximum.

40 X-Q. Will you please state what percentage of the amount of ore figured as a whole these quantities of oil named in your last answer represent?

A. Reckoned in percentages, the minimum is 0.48 per cent. and the maximum is 0.71 per cent.

(Pages 181-183):

42 X-Q. In treating an ore containing eight per cent. of zinc as blende and the remainder consisting of non-metalliferous gangue, what would be the maximum and the minimum amounts of oil per ton of ore to be used according to the instructions appearing in lines 28-30, page 1 of patent No. 835,120, this being the patent in suit? Will you also apply the same question to an ore containing four per cent. of zinc in the form of blende?

A. The patent in suit, as I understand it, does not specify any particular quantity of oil with regard to the percentage of zinc present in the ore. The specification simply gives general indications of possible quantities that might be found useful. In lines 28-30, to which you refer in your question, no specific quantity is mentioned. The inventors simply state, referring to the Cattermole patent which has just been previously discussed, that four to six per cent. of the weight of metalliferous matter present is employed; that they have

found that if the proportion of oily substance be considerably reduced, say, to a fraction of one per cent. on the ore, granulation ceases to take place. What this fraction of one per cent. is, they do not mention. The only way in which I can interpret this fraction of one per cent. is by referring to other portions of the specification, where this fraction of one per cent. is expressed in figures; for example at line 81, of page 1, of the specification is the following statement, speaking of the ore:

> "To this is added a very small proportion of oleic acid (say from 0.02 per cent. to 0.5 per cent. on the weight of the ore)."

That is, from 1/50 of one per cent. up to one-half of one per cent. The specification does not intimate that these proportions of oil or oleic acid are to be used indiscriminately on the ores. Special directions are given for preliminary tests with different ores and different oils. Consequently it does not follow from the specification that the maximum quantity of oleic acid mentioned would be used on four per cent. or eight per cent. ores. On the contrary, it is especially stated, beginning at line 96 on page 1 of the specification:

> "The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1% of the ore, but this proportion has been found suitable and economical."

(Pages 183-184):

43 X-Q. We will refer again to lines 28-30, page 1, of the specification of the patent in suit, and in connection therewith I would like you to state whether 9/10 of one per cent. is not "a fraction of one per cent."

A. It certainly is, but the paragraph does not indicate that that is the fraction that the inventors refer to. We have to seek further information in the specification to

ascertain what particular fraction they are referring to by the expression "a fraction of one per cent."

(Pages 184-185-186):

46 X-Q. You have stated in discussing lines 28-30, page 1, of the patent in suit that it is necessary to seek further information in the specification of that patent to ascertain what particular fraction of one per cent. of oil is referred to. Will you kindly point out in this patent any passage definitely setting forth any particular fraction of one per cent. that is applicable to the treatment of ores generally?

A. I will examine the specification in its entirety and see what I can find. The first reference to any proportion of oily substance is found in the lines which you have referred to on page 1, lines 28-30. That paragraph, however, is not a statement of any particular quantity which the patentees recommend. It is simply a statement of a discovery which the patentees have made. The first definite statement which I find as to quantity of oily matter is given on page 1, line 81, after the patentees have stated the desirability of simple preliminary tests. At line 81, the patentees say:

> "To this is added a very small proportion of oleic acid (say, from 0.02 per cent. to 0.5 per cent. on the weight of the ore)."

These extremes represent from .4 of a pound per ton of ore to 10 pounds per ton of ore. The patentees do not state on what particular condition of the ore this variation of quantity depends, whether it depends upon the percentage of zinc in the ore or some other quality, but they do indicate that the selection of quantity between these extremes must rest with the person familiar with the art who practices the process, and it is fair to assume that such person would decide how much oleic acid

to use by the results of the simple preliminary tests suggested by the patentees.

The next place in the specification where I find a reference to the proportion of oleic or oily matter is at line 99 on page 1, where I find the following statement:

> "The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical."

0.1 per cent. of the ore is two pounds to the ton.

And further I notice that in all of the claims in suit the amount of oily liquid is specified either as a fraction of one per cent., as in claims 1, 2, 3 and 12, or as a small quantity, in claims 9, 10 and 11, or in a percentage in the case of oleic acid .02 to .50 per cent. in claims 5, 6 and 7.

(Pages 187-188):

48 X-Q. The teaching of the patent, as I understand you, consists in directions to perform experiments with different amounts of oil and acid until that amount is hit upon which produces a froth, and then adopting that amount, and that the determination of what is intended to be included within this patent is defined by a result as distinguished from any definition of means to secure such result. Is this correct?

A. As I understand it, the object of this invention as described in the specification and claims is to extract as completely as practicable the valuable metallic minerals from the ore.

This result is to be accomplished in a certain way, which is described and claimed in the patent, that is, by agitating the ore in extremely fine powder in water which is slightly acidulated and to which a minute quantity of oily matter is added, these additions and the

character of the agitation being such as to cause the metalliferous particles to come to the surface as a froth, while the worthless gangue minerals remain at the bottom of the vessel. Now it is self-evident that no two ores are exactly alike, either in the nature of their metallic minerals or in the percentage, and it is equally self-evident that, that being the case, no hard and fast rule can be laid down for all cases as to the quantities of acid or oily matter to be employed. All that the inventors can say in their specification and claims is the statement as to about how much, in general, acid and oil they have found to accomplish the desired results on ores containing metalliferous minerals.

I don't think your question correctly expresses the teaching of the patent. It is not merely necessary to "produce a froth." One might produce a froth and not get out half the valuable material in the ore. Anyone skilled in the art would understand that he must conduct his preliminary tests until he has ascertained the amount of oil and acid which this particular ore requires for its successful working by the process of this patent. This process does not merely consist in adding oil and acid to the water containing the pulverized ore, but it consists in agitating, agitating it briskly, as the specification says, and agitating it so as to produce a froth which shall contain the valuable metallic minerals of the ore.

(Pages 189-190):

49 X-Q. In following out the directions of the patent in suit, do you find anything in that patent to define the amount of oil to be used other than the results secured by using different amounts of oil, such results taking into account not only the production of a froth, but the amount of valuable mineral carried by the froth, as you have suggested?

A. I find on page 1 of the patent, beginning at line 96, the following statement, which I have already quoted:

> "The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical."

This paragraph certainly contains a direction defining the amount of oil which the patentees find to be suitable and economical. In another place they have intimated that the quantity is not necessarily fixed for all ores and that the person skilled in the art practicing the process should make preliminary tests or, at least, may make them, with his particular ore, to discover, if possible, a more suitable proportion than 0.1 per cent. or under. I am trying to see what else your question calls for in the way of an answer. You ask me, "do you find anything in that patent to define the amount of oil to be used other than the results secured by using different amounts of oil?" I think the last three words in my quotation from the patent cover everything that is possible, where, in speaking of the proportions to be used, he uses the words "suitable and economical." Necessarily the proportion suitable is the proportion that will cause the largest possible percentage of the valuable metallic minerals to rise in the form of froth, while the largest possible percentage of worthless gangue remains at the bottom of the vessel.

And "economical" naturally refers to costs, which would mean the oil or its equivalent and the proportion thereof which accomplished the desired result at the least expense. I don't mean to say that I find in the specification that it is anywhere stated that one must select the oily matter and determine the proportion thereof which will be most efficient and least ex-

pensive. Anyone skilled in the art would read them into any patent. The object of every patented process is to accomplish a result for commercial purposes, and such considerations are always understood.

(Pages 207, 208, 209):

78 X-Q. Will you explain the distinction as to the quantity of oil or oily liquid used between those of the claims of the patent in suit which specify a fraction of one per cent. as the amount of oil or oily liquid, those which specify a small quantity, and those which specify .02 to .5 per cent. on the ore as the quantity of oily matter or oil?

A. The object in employing oily matter in the process of the patent in suit is clearly set forth in the specification. It is further clearly stated that, while a great variety of oils and oily substances may be employed successfully, there is a choice among these oily materials which depends upon the character of the ore, and the inventors direct that a simple preliminary test should be made to determine which oily substance is suitable to carry out the process with any particular ore. When the patentees specify, either in the specification or claims 1, 2, 3 and 12, a fraction of one per cent. of oily matter, they speak of it in the first three of those claims as oily liquid, and in the twelfth claim as oil, thus providing for a sufficient quantity of any oily substance suitable for carrying out the process of the patent.

In claims 9, 10 and 11 no maximum figure is given for the amount of oil to be employed. The expression is simply "a small quantity of oil," which, as I understand the language of patent literature, would mean a quantity small enough to accomplish the result described and claimed in the patent, the specification of which

clearly indicates that, although the quantity may be variable, it is somewhere about one per cent. or under.

The patentees have selected as the oil to be used in their example oleic acid, and claims 5, 6 and 7 mention this particular oily substance and also mention a proportion which may vary from 0.02 to 0.50 per cent., having evidently found that this is a sufficient margin of variation in quantity, and, referring to the specification, I note that they state, in speaking of the particular ore which they select for their example, line 96, page 1:

> "The minimum amount of oleic acid which can be used to effect the flotation of the minerals in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical."

79 X-Q. I invite your attention to claims 1 and 9 of the patent in suit and ask you whether the expression "a fraction of one per cent. on the ore," appearing in claim 1, has the same significance as the expression "a small quantity," appearing in claim 9?

A. As a layman and with great diffidence I answer your question by saying that, as I understand the difference in those two expressions, claim 1 limits the amount of oil to a fraction of one per cent. on the ore substantially, while claim 9 limits the quantity of oil not to any particular percentage, but to such a small quantity as will produce the desired froth, which is necessarily variable with different oils and different ores, and may in some cases exceed one per cent.

(Page 212, answer to 84 X-Q.):

I notice, on comparing these two claims, that claim 10 is a claim in which "a small quantity of oil" is directed with no reference to any special oil, and the exact degree of warming is not specified. The claim is

general, for any oil, and the warming could be varied to suit the oil and the ore. Claim 7, however, is an oleic acid claim, and here a specific temperature is mentioned, namely 30°-40° Centigrade, which is equivalent to 86°-104° Fahrenheit, the patentees having probably found that this is a suitable temperature with oleic acid; so this is a more specific claim.

George A. Chapman.

(T. R., Vol. II, page 245):

22 Q. And after these adjustment runs was it put to work treating ore, and, if so, for how long?

A. We started the plant on dump tailings, and treatment proceeded along the Cattermole line for but a few days. The oil consumption alarmed our clients, and I was instructed to use every endeavor to bring this down. This was only possible to the extent of .8 per cent. on the weight of the ore. The formation of good shotty granules was impossible under these conditions, mineral flocks being formed, and these readily separated on the skin flotation table on the lines in which I had been instructed by Messrs. Sulman, Picard and Ballot previous to my departure for Australia. These trials took considerable time, and it was a few weeks before this best condition was reached. The plant proceeded to run on these lines.

(Pages 263-264):

51 Q. You have said it is part of your work to carry out tests on ores. Please describe the manner in which you customarily test an ore for the purpose of determining whether or not it can be successfully treated by the agitation-froth process.

A. The ore to be tested is suitably powdered or pulverized. I usually use the Sulman & Picard slide machine, sometimes known as a "shear-mixer." Into this slide machine I place sixteen hundred grammes of water and in it place four hundred grammes of the ore to be tested. I add acid to equal twenty pounds per ton of ore to be tested and note the effect of such an addition. If a violent evolution of CO_2 takes place I know that calcite is present in the ore in disturbing quantities.

By disturbing quantities I mean that the ore would require large quantities of acid in the treatment, and for economy's sake I abandon the test and use certain acid salts, such as are advised in the patent in suit. The choice of oil for treatment is decided by the locality of the mine, and if possible I use an oil that is locally produced and is as cheap as possible. Having settled upon the acid condition I add roughly one and a half pounds of oil per ton of ore and agitate vigorously for about two minutes. The machine is stopped and the contents of the slide-machine examined. If a good coherent froth is not formed I know that I have to make some slight modification in the reagents used. To any one well trained in the agitation-froth process it is a simple matter to adjust the conditions so as to produce a good, thick, matted, coherent froth.

(Page 265):

To conclude, the conditions of re-agents, that is to say, oil, acid or acid-salts, are suitably combined with the temperature and agitation conditions so that the cost of operation would be a minimum. In all the slide machine tests that I have conducted I have never had to use quantities of oily re-agents outside those mentioned in the patent in suit. The greatest amount of oil that I have ever used in practice is four pounds per ton of ore, and the smallest amount I have ever used in practice is one pound of oil per ton of ore.

(Pages 279-280):

96 Q. Now as to the agitation-froth plant at the Emu Works in South Wales, what oil was used and what amount per ton of ore?

A. We used oleic acid amylacetate and on occasions Karsam soap. The consumption of oleic acid was, roughly, two pounds per ton. The soap, when being

used with the oleic acid, about .2 pounds per ton. Amyl-acetate, when being used with oleic acid, from .25 pounds per ton up to .5 pounds per ton. Amlyacetate, when being used alone in the first test, about one pound per ton.

(Page 281):

102 Q. Now as to the plant installed by you in Finland, what oil was used and in what amount per ton of ore?

A. We used oleic acid and eucalyptus oil. The two oils were added at the following rates: Oleic acid from .5 to two pounds per ton; eucalyptus oil, .2 pounds per ton.

(Pages 281-282):

104 Q. Now, as to the plant installed by you at the Saxbergets Mine in Sweden, what oil was used and in what amount per ton of ore?

A. We used a very cheap locally obtained wood tar oil. We used four pounds per ton of ore treated.

(Pages 282-284):

109 Q. About what relation have you found to exist between tests in the slide machine and the actual working of commercial plants, when the agitation-froth process is tested and used?

A. The results produced by the agitation-froth process in practice have been, on every occasion that has come under my own personal observation, an improvement on the result obtained in the slide machine. The improvements were not only those of recovery, but in the consumption of re-agents.

110 Q. What has been your experience when, in using the agitation-froth process on a commercial scale, with a normal and proper consumption of one and a half

pounds of oil per ton of ore, this procedure has been varied by increasing the oil feed to two and a half pounds per ton of ore?

A. The mineral froth being produced on the spitz boxes loses at once some of its natural color and lustre and becomes dull in appearance. The quantity of froth being recovered on No. 1 box is considerably lessened. The froth on No. 2 spitz is slightly increased and the same with No. 3 box. The tailings on examination immediately show increased losses of sulphide mineral. These losses take the form of well oiled agglomerations.

111 Q. And what has been your experience when the normal and proper feed of one and a half pounds of oil per ton of ore has been diminished to half a pound of oil per ton of ore?

A. The froth being recovered immediately diminishes in quantity and the color shows the presence of slime gangue. The supporting liquor of the spitz box immediately changes in appearance and shows the natural color of the ore slimes. The tailings become very dirty and show no sign of what we know as a good "clean-up." In fact, the whole treatment suffers and unless the oil feed is restored to its normal condition a serious drop in recovery takes place with the production of a lower grade concentrate.

(Page 292):

138 X-Q. Did you ever make any tests of the operations set forth in the patent in suit by performing those operations in a bottle or test tube?

A. Yes.

139 X-Q. Will you describe how you did it?

A. I would take a bottle of a capacity of, say roughly, 100 cc. and in it place 20 grammes of ore and 70

grammes of water. To this I would add sulphuric acid to equal roughly twenty pounds of acid to the ton of ore. To this I would then add oil by drops equivalent to one and a half to two pounds of oil per ton of ore, and agitate vigorously. These tests would serve as an indication only, and would be used to indicate the condition for the first investigations when using the Sulman & Picard slide machine. I would never use a bottle test to obtain quantified results and would only use it for the reason I have just mentioned.

(Pages 295-296):

154 X-Q. Did you ever try the Froment process with oil amounting by weight to one per cent. of the ore being treated?

A. The quantities of oil I used in the Froment test were always between 60 and 120 pounds per ton, which equals roughly, from 3 to 6 per cent. of the weight of ore.

155 X-Q. Did Mr. Sulman instruct you to use these amounts of oil?

A. I was working entirely under Mr. Sulman's instructions.

156 X-Q. Did Mr. Sulman ever instruct you to try the Froment process with an amount of oil that would just produce a film upon the sulphide particles?

A. No.

157 X-Q. What kinds of oil did you use in experimenting with the Froment process?

A. We used the same oils in the Froment process as we did in our work on the Cattermole process.

(Pages 317-318):

223 X-Q. You have been asked what your experience was when, in using the agitation-froth process on a commercial scale, with a normal and proper consump-

tion of one and a half pounds of oil per ton, you increased the oil feed to two and a half pounds of oil per ton, and you stated that the mineral-froth lost some of its natural color and lustre, that the quantity of froth recovered on No. 1 box was lessened, that on No. 2 spitz and No. 3 spitz was slightly increased, and that the tailings showed increased losses of sulphide mineral, taking the form of agglomerations. Suppose you had increased the amount of oil under the conditions of the question referred to to five pounds per ton of ore, would the defective conditions have been still further increased?

A. Certainly.

(Pages 318-319):

226 X-Q. You have said that with the oil reduced to half a pound per ton of ore the froth immediately diminishes in quantity and the color shows the presence of gangue. I take it that you have experimented, or experienced in practice this condition of half a pound per ton. Is that correct?

A. Yes. I have experienced this condition on occasions when I have been demonstrating to our clients at Broken Hill that it would be impossible to reduce the oil consumption below that at which we were operating, and so reduce the cost of treatment. I mean, of course, reducing oil consumption without loss of recovery or in any way affecting the practical value of our work.

227 X-Q. You would not expect successful results with fifteen or eighteen pounds of oil per ton under those conditions where a pound and a half per ton was the proper and normal feed?

A. You could get successful results on this quantity of oil by varying the conditions of agitation, namely, I should expect to have to make repeated agitations to

beat more air into the pulp. I cannot say this definitely because I have never tried this wasteful quantity of oil in practice.

228 X-Q. It is your idea then that with the larger amounts of oil more agitation would be necessary?

A. In this particular instance the agitation that would be necessary would be far beyond practical limits.

229 X-Q. But whether practical or not, more would be necessary to produce the result?

A. I should expect so. The purpose of the extended agitation in this case would be for beating air into the pulp, and not for the oil coating of the mineral.

William H. Ballantyne.

(T. R., Vol. II, pages 362-363):

The next process of ore concentration by the use of oil which was to any extent successful in practice was the Cattermole process. I first saw tests of this process carried out by Mr. Cattermole in small bottles at the end of 1902. From that time onwards Messrs. Sulman, Picard & Ballot, with various assistants, were engaged for about two and a half years experimenting with the Cattermole process described in the United States patent No. 777,273, and exploiting the invention. Briefly stated the process is as follows: Finely crushed ore containing sulphide minerals is mixed with four times its weight of water (generally acidified) and to this is added a small quantity of oil or oily emulsion, the proportion of oil varying from forty-five pounds per ton of ore to seventy pounds per ton or more in certain cases. The mixture was agitated, first in a very violent manner so as to bring the oil into intimate contact with the sulphide particles. At this stage the oiled sulphides have agglomerated together into small flocculent masses called "flocks." Thereafter the mixture was subjected to a rolling form of agitation to cause the agglomerates to form into shotty granules.

(Pages 364, 365, 366, 367, 368, 369, 370, 371):

10 Q. Please now relate the facts within your knowledge which led to, and culminated in, the invention of the patent in suit.

A. As I have stated, from the end of 1902, onwards I have been in constant touch with Messrs. Sulman, Picard & Ballot. . . .

Almost from the start another aim which Sulman, Picard and Ballot expressed to me was the reduction of the quantity of oil to be used in the Cattermole

process. At the beginning of January, 1905, Messrs. Sulman and Picard informed me that they had been appointed by Messrs. Minerals Separation, Ltd., to take full technical control of the experimental work of that company and to take the technical control of the test works at Aldermanbury avenue. They expressed themselves as very pleased because they were anxious to work out to finality the process of ore concentration by the use of small quantities of oil. Mr. Ballot was then, as now, the Managing Director of Minerals Separation, Limited, and during the first three or four months of 1905 investigations and discussions were taking place practically every day between Messrs. Sulman, Picard and Ballot and myself. In or about the first week of February, 1905, at a conference at 62 London Wall, these gentlemen informed me that they had decided to get to the bottom of their loose-end observations, and for that purpose they had decided to investigate and quantify all the factors connected with the Cattermole granulation process. They informed me that they had drawn up a series of tests which they were proceeding to carry out, and they intended to have the results all plotted in curves, and we discussed the method of indicating the results. I particularly remember these gentlemen informing me at this time that they "intended to reduce the proportion of oil to a vanishing point," indeed, I believe these very words were used. At the end of February, 1905, Sulman, Picard and Ballot devised the process described in the British patent No. 5260 of 1905, a process in which no oil is used at all, and I remember saying to them at that time (February, 1905), "you have indeed reduced the quantity of oil to a vanishing point." I only mention this to fix the dates, as this patent to which I have referred had nothing to do with the investigations of the various factors of the Cattermole process.

From the 8th of March, 1905, to the 15th of March, 1905, I saw Messrs. Sulman, Picard and Ballot nearly every day. On one of these days, I cannot fix the actual date, they informed me of their startling discovery of the agitation-froth process. To the best of my recollection, Mr. Ballot went out of town for some days thereafter, and it was not until the 31st of March, 1905, that we got together again and fully discussed the protection of the invention of the patent in suit. One of the first days of April, 1905, I attended at the Aldermanbury Avenue Works with Messrs. Sulman, Picard and Ballot, and they demonstrated their process to me. Broken Hill tailings crushed to 60 to 90 mesh were mixed with slightly acidified water and introduced into the ordinary Gabbett of the Cattermole test plant. 0.1 per cent. of oleic acid was added, and the whole pulp was heated to a temperature between 30 to 40° Centigrade. After violent agitation in such a way as to introduce air into the pulp, the agitation lasting for several minutes, the pulp was brought to rest and immediately a coherent and persistent froth rose to the surface. Although I was very closely familiar with all the earlier processes of ore concentration in which oil had been used, including all the prior patents which have been mentioned in this suit, the production of this agitation-froth was to me little short of a miracle. I had never seen anything of the sort before, and I recognized that Messrs. Sulman, Picard and Ballot had at last reached success in their investigations and had devised a process which would economically and successfully concentrate ores.

Summing up the above, Messrs. Sulman, Picard and Ballot first installed the cone mixer and started working along the lines of violent agitation and from an early date in 1903. Secondly, they found it most advan-

tageous to use oleic acid in their investigations. Thirdly, they found that the heating of the pulp had an influence upon the oiling of the metalliferous matter, and this led them to experiment with heated pulps when going into details of their final tests. Fourthly, they determined to experiment with finely crushed ore containing a high proportion of slimes, and they did so. Fifthly, they determined to reduce the quantity of oil to a vanishing point, and to do it step by step so as to ascertain the results obtainable throughout the range of reduction, in each case using the slimy pulp, the violent agitation, and various degrees of temperature; and using also a pulp acidified to the extent to which they were accustomed in their previous investigations.

I have seen the agitation-froth process carried out many hundreds of times. I have also seen investigations of the process making wide variations step by step in the factors which I have referred to above, and I have myself, on many occasions, carried out these investigations and I now know that if the instructions which Messrs. Sulman, Picard and Ballot drew up in February, 1905, are carried out, namely, to use a slimy pulp, acidified with say .5 per cent. of sulphuric acid, to heat the pulp say to 30° Centigrade and then to agitate it violently with proportions of oil beginning at fifty pounds of oil per ton of ore and repeating this test, reducing the quantity of oil step by step down to the vanishing point, it is inevitable that the agitation-froth shall be produced when the quantity of oil is diminished to the limits set forth in the patent in suit, and that a particularly good froth and efficient concentration is obtained when the proportion of oil is about 0.1 per cent. on the ore, the percentage recommended in the patent in suit as being suitable and economical. I also know that the oil selected by Messrs. Sulman, Pic-

ard and Ballot, namely oleic acid, is one of the best and in most cases the best oil that can be used for carrying out the agitation-froth process.

(Pages 399-400):

31 Q. Assuming that powdered ore, water acidified with sulphuric acid, and oleic acid, are fed into the defendant's apparatus referred to in the last question, what have you to say as to what would happen?

A. Firstly, if this operation were performed so as to produce a floating froth of concentrates in the spitz boxes, the operation could only be consistent with the use of the agitation-froth process as described in the patent in suit. Secondly, if the amount of oleic acid used were too low to produce the agitation-froth, it is obvious that the froth would not be produced. Thirdly, if the amount of oleic acid were in excess of that necessary to produce the agitation froth in the most efficient and economical way, part of the sulphide contents of the ore would be agglomerated into little flocks which would sink in the spitz box and the froth would no longer be a good and efficient froth.

(Page 407):

48 X-Q. The illustration of the Gabbett A in Figure 1 of the drawings of the patent in suit illustrates the outer cylinder or containing vessel as transparent, shows the cone mixer inside of the vessel, shows the shafts supporting the cone mixer, the bearings for the shafts, the pulley for rotating it, inlets for the various reagents, and for the ore, and also shows the outlet. In what respect is this illustration conventional in the sense in which you have referred to the pump as conventional, in other words, are not all of the various parts shown in detail except the baffles?

A. . . . The illustration of the cone mixer is conventional for two reasons, first, because the cone mixer was a well-known device, and, secondly, because the patent is for a process, in which it is clearly stated that the ore pulp and a minute quantity of oil is to be vigorously agitated until the oil has been brought into efficient contact with all the mineral particles in the pulp, etc.

(Page 410):

51 X-Q. Do you remember having any consultation with Messrs. Sulman, Picard and Ballot regarding the instructions given to Mr. Higgins to vary the different factors in the effect of those factors upon granulation, as set forth in Sulman and Picard's Report, March 3, 1905?

A. I had nothing to do with the drawing up of any instructions to the assistants of Messrs. Sulman, Picard and Ballot; indeed, beyond Mr. Chapman, Mr. Reed and Mr. Leechman, I did not know the assistants' names. I do remember in the early part of February, 1905, having a consultation with Messrs. Sulman, Picard and Ballot, at which they spoke of the investigations which they were about to make, and we discussed the method in which the results were to be indicated; and I particularly remember these gentlemen stating to me that in their investigations they were going to reduce the proportion of oil used in the Cattermole concentration process to a vanishing point, making the reduction step by step, and noting the results.

(Page 411):

53 X-Q. Did you approve of this project to experiment with varying quantities of oil in the investigation of the granulation process?

A. I merely listened to what was told to me; I offered no opinion on my clients' projects.

(Page 412):

55 X-Q. Does the process which you call the agitation-froth process always result in the production of this phenomenon which you term a thick, coherent and persistent froth as distinguished from the froth of bubbles which you say you have seen produced by the Froment procedure?

A. The process which I call the agitation-froth process is the process set forth in the patent in suit, and when that process is normally operated to its proper purpose and effect it results in this very characteristic phenomenon which I term a thick, coherent and persistent froth. The process as a whole is entirely distinct from the Froment procedure and the froth produced by the process of the patent in suit is quite distinct from anything which I had seen produced by the Froment process. The froth of bubbles which I had seen produced by the Froment procedure was produced in a test tube.

(Pages 427-429):

77 X-Q. The froth produced in the operation of the so-called agitation froth process is composed, is it not, of a large number of bubbles, more or less covered with the metallic sulphide particles of the ore?

A. In answering this question I shall have to make statements bordering on theory, and I am, therefore, expressing only my opinion. It is known to students of molecular physics that a persistent froth of air and water cannot be produced unless the water films are contaminated. In my opinion the froth produced in the operation of the agitation froth process set forth in the patent in suit is composed of bubbles of air, the

walls of which consist of water contaminated with myriads of particles of very finely divided sulphides, and the surface tension relationship between the sulphide particles on the one hand, and the water and air on the other hand, has been altered by the minute trace of oleic acid or other oil. An inspection of the agitation-froth shows that the walls of the bubbles are contaminated by these sulphide particles; and it is a fact that the agitation-froth process operates most effectively when a large proportion of the sulphides is in the form of slimes; that is to say, when a large proportion of the sulphides will pass through a screen of 150 or 200 meshes to the linear inch. It is noticeable in the agitation-froth process that the sulphide particles still retain their natural appearance, and they are not in the form of flocks.

78 X-Q. In any event, the froth formed as a result of the operation of the so-called agitation-froth process consists of bubbles, the walls of these bubbles being formed of water contaminated by or containing metal sulphide particles, the formation of such sulphide-bearing bubbles being promoted by the oil present. Is this not correct, disregarding for the moment any scientific discussion of the minutiæ of the matter?

A. This is correct, and it is a remarkable fact that this characteristic agitation froth can only be produced by the process described in the patent in suit, so far as I am aware.

(Pages 435-436, answer to X-Q. 81):

. . . Turning to the agitation-froth process described in the patent in suit. It is clearly stated on page 1, line 96, "the minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of a froth may be under 0.1 per cent. of

the ore; but this proportion has been found suitable and economical." This statement clearly directs the metallurgist to use 2.24 pounds of oil per ton of ore or less, and my experience is that 2 pounds ~~of ore~~ by one and a half pound of oil per ton of ore is an ideal standard for the agitation-froth process. In the agitation-froth process the minute trace of oil added is not proportioned to the metalliferous constituents of the ore. In my opinion a metallurgist in putting into operation the agitation-froth process would start with 0.1 per cent. of oleic acid on the ore, and this would probably give him a good result. If he found that there was a tendency for some of the metalliferous particles to agglomerate together and sink he would reduce the quantity of oil from say 2 pounds of oil per ton of ore down to say 1½ pounds of oil per ton of ore.

Apart from these considerations as to the proportion of oil used which bring out fundamental distinctions between the Froment process and the agitation-froth process, I wish to say that no fanciful or imagined variations in the quantity of oil necessary in the Froment process could possibly convert the Froment process (which depends upon certain phenomena) into the agitation-froth process, which depends on a very unique, characteristic and entirely distinct phenomenon.

Referring again to the first reason set forth in my answer to 80 X-Q., the quantities of oil necessary in the Froment process would be quite unsuitable to cause the formation of an agitation-froth.

(Pages 437, 438 and 440):

82 X-Q. Suppose you were treating an ore containing five per cent. of zinc sulphide, the rest of the ore being gangue of such a character as not to interfere with the flotation of the blende, and that you used suitable oil in quantity equal to 1 per cent. by weight of the

ore, agitated the pulp in a suitable apparatus, such as a Gabbett mixer, it being presupposed that the ore contains either naturally or by addition thereto one per cent. of calcite, and that sufficient sulphuric acid has been added to react with all of the calcite, that after agitation the Gabbett is stopped and the blende allowed to float, would not each step so performed be in accordance with Froment's patent as directed in lines 33 to 39, page 2 of the British specification, except for the adjustment of the quantity of calcite and oil to the figures mentioned in his instructions? My question is not directed to ascertaining what results would be obtained by this operation, or what form of float would be secured, but is directed towards ascertaining whether the steps set forth in the question, irrespective of the result produced, would not conform to Froment's British patent and instructions as defined in the preceding part of the question.

A. The last sentence of your question contains suggestions with which I entirely disagree. For example, the agitation-froth process does not consist in a series of steps, but embodies, as I have stated, a unique and very remarkable phenomenon. In short, the agitation-froth phenomenon is produced by agitating the ore pulp with a minute trace of oleic acid or other suitable oil, so as to form the agitation-froth, and the proportion of oil recommended in the patent in suit is 0.1 per cent. on the ore or less. . . . The quantity of oil being about ten times the amount necessary for the production of an agitation-froth (that is to say, ten times the amount stated in the patent in suit to be suitable and economical), I should next expect that the oiled sulphides would agglomerate together into little loose flocculent masses. The beating in of air in the Gabbett would, in my opinion, effect an air-attachment to some of these flocculent masses; and when the agita-

tion is stopped I should expect that the great bulk of the flocculent masses of oiled zinc sulphide would sink with the gangue and possibly there would be a little floating oily matter, some floating flocks with air-attachments.

(Pages 448-449):

99-X Q. You answer upon the theory that all of the oil becomes attached to the metalliferous particles, do you not?

A. I answer upon the theory that all of the oil either becomes attached to the metalliferous particles or floats.

100 X-Q. Would this be the case also in what you term the agitation-froth process?

A. The proportion of oil used in the agitation-froth process is one and a half pounds or two pounds per ton of ore (*i. e.*, about 0.1 per cent. or less as recommended in the patent in suit). This is a very minute quantity, and in my opinion the oil furnishes a microscopic film on the sulphide particles. In the agitation-froth process it is a fact that practically all of the oil becomes attached to the metalliferous particles, but the quantity is so small that it cannot be seen under the microscope.

(Pages 449-450):

102 X-Q. Then this so-called agitation-froth process even by the terms of the patent may be conducted, under some circumstances at least, by the use of an amount of oil equal to practically one per cent. by weight of the ore, or, to conform to the precise directions of the patent, less than one per cent. by an amount infinitely small, say .9999 per cent. This last amount of oil would be a fraction of one per cent., would it not, as contemplated by the patent?

A. In my opinion the operation of the agitation-froth process is defined in the clearest possible terms in the patent in suit, and this remark applies particularly to the quantity of oil to be used. It is a fact that 0.1 per cent. of oil on the weight of ore is a suitable and economical quantity to use for the production of the agitation-froth, in the instance given in the patent and in those instances where I have seen the process in use. Less oil than this may also in some instances be effectively used, as stated in the patent in suit. It is further made clear in the patent in suit that the quantity of oil used must not be such as to cause agglomeration, as in the Cattermole process. If a metallurgist used a quantity of oil sufficient to cause the sulphide particles to agglomerate and sink, he would be using too much oil for the process of the patent in suit; and, further, if a metallurgist was minded to carry out the agitation-froth process as defined in the patent in suit, and if he used more oil than is necessary to produce the agitation-froth, he would be doing something wasteful, and in ore concentration economy is of first-rate importance. The fact is that Sulman, Picard and Ballot found that when the proportion of oily substance was considerably reduced from the Cattermole quantities, and after vigorous agitation of the pulp, the tendency of the froth to form began; and when the proportion of oil was reduced to 0.1 per cent. they found that an efficient agitation-froth was produced. I have never seen the agitation-froth process successfully carried out by the use of an amount of oil equal to practically one per cent. by weight on the ore, and in my opinion 0.9999 per cent. of oil would not be a proper quantity (that is to say, it would not be a suitable and economical quentity), as contemplated by the patent, and would not therefore be a suitable fraction of one per cent. as contemplated by the patent.

Dr. Adolph Liebmann.

(T. R., Vol. II, pages 531-534):

5 Q. Having in mind the state of the prior art as disclosed by the several patents referred to in defendant's testimony, please give consideration to the invention shown, described and claimed in the patent in suit, and give such explanation thereof as will assist the court in its understanding of that invention.

A. Having carefully considered the objections raised by the defendant and disclosed in the different patent documents, which I may say represent practically the whole history of this branch of ore concentration, I have formed the opinion that the invention now in controversy is an entirely novel, ingenious and unexpected process, which by its great simplicity fulfills the most ideal demands of ore concentration.

. . . . . .

The present invention differs essentially from all previous attempts. It is true that oil is one of the substances used, but it is used in such quantities which were never heard of, and it produces a result which was never obtained before. The result is that the minerals are obtained as a froth of very peculiar character. It is a froth consisting of air bubbles, which in their covering film have the minerals embedded in such manner that they form a complete surface all over the air bubbles. The remarkable fact with regard to this froth is that, although very light and easily destructible air bubbles are covered with a heavy mineral, yet the froth is stable and utterly different as far as this property is concerned from any froth known to me. It appears as if the minerals were protecting the tender air bubble like an armor, and, instead of destroying it, were actually guarding it. The froth has a long life. One feels

tempted to say it is permanent, at least as far as the metallurgical operations are concerned. I have myself seen a froth standing for twenty-four hours without the least change having taken place. Further, a very striking difference between the previous processes and the process of the patent in suit is the difference between failure and success. This I will explain more fully hereafter.

The simplicity of the operation as compared with the prior attempts is startling. The whole work which has to be done is to add an infinitesimal quantity of oil to the pulp, to which one may or may not add an acid, agitate from two and a half to ten minutes, and collect the froth which appears after a few seconds collecting on the surface. The froth contains a large percentage of the minerals present in the ore. For continuous work nothing is required but an agitator, which is connected with another vessel, such as a spitzkasten, from which the concentrates overflow as a thick froth.

The appearance of this froth is most remarkable. The color and lustre of the minerals is the same as if no oil were present. It is very strong and, even if the top layer is destroyed, the underneath layers will bear it without being destroyed themselves and carry the mineral fallen from the top layer along. No air bubbles are visible—nothing but the uninterrupted covering formed by the concentrates.

(Pages 575-576):

Cattermole has described in the text of his patent a rolling form of agitation as preferably to be used in some stages of the process to obtain a good granulation of the mineral, this rolling to be such as is had in cylinders or barrels. This appears at page 3, lines 46-50. This is not shown in the drawings. Of course, a cylinder or barrel could be used in place of any cone

mixer which is shown, and it would be reasonable to put cylinders or barrels in place of the last two cone mixers. Indeed, it would be self-evident that this would be the place to use the rolling form of motion, as the first set of cone mixers could then be relied upon to intimately mix the oil with the mineral.

The proportion of oil used depends on its viscosity, the fineness of the ore and other factors, and on the consistency and size of the granules desired. The more oil used, the larger, softer and less numerous the granules. With 10 per cent. of oil to the weight of minerals, only a few pasty masses of oil agglomerated minerals will be generally obtained, and oil in excess of this quantity may cause all the granules to coalesce into one soft mass. Cattermole recommends a quantity of oil between 4 and 6 per cent. of the weight of the metalliferous mineral matter present in the ore, but this is only a recommendation and a statement of what he has usually found to be necessary. It is clear from this description that a definite amount of oil to produce good granulation effects cannot be given, as the final result is determined by many factors which have to be first experimentally ascertained. No definite law of proportions can be laid down for this process, which is a process for the treatment of a large class of substances, each differing from the other in many ways, and is in that respect like all other processes which are destined for the use of differently constituted compounds and not for the use of one individual substance. But the patentee has described his invention so well and exhaustively that a few experiments will suffice to determine the proper proportions suitable for a given ore.

(Page 588):

Experiment IV was carried out with proportions of oleic acid which fall within the Cattermole range. 20 lbs. of ore were mixed with 60 lbs. of water and 4 oz. of oleic acid (1.25 per cent. on the ore and about 4 per cent. on the mineral) were mixed in a cone mixer for five minutes. After agitation, a partial layer had formed on the top containing very little mineral. Imperfect granules, which owing to slime and not quite sufficient oil, were not as compact as the usual Cattermole granules, were at the bottom. The mixture was conveyed into the helix apparatus described in the previous experiment and the helix was rotated with a speed of 240 revolutions per minute, whilst at the same time air was blown in. The result was an aggregation of pasty particles on the surface, which floated as skin flotation.

(T. R., Vol. III, pages 677-679):

Dr. Byrnes states that he has produced in the first experiment of the series a froth of concentrates. There is nothing surprising in this. He used the process which for the first time in the history of ore concentration was revealed in the patent in suit, and he practically used the quantities which are described therein as being suitable and economical. He commingled, by brisk agitation, air, ore and traces of oil, traces so small that they cannot be translated into the test tube experiments of Froment. He produced the agitation froth. He did not learn that from Froment, but he learned it from the patent in suit. He then used the same process with very much larger quantities of oil and states again that he obtained a froth. There may be what is popularly called a froth, but this froth differs in characteristic qualities from the froth produced

with the quantities of oil described by the patentees of the patent in suit as suitable and economical. It contains large quantities of oil which are quite visible and can even be detected by the touch. The appearance of the minerals is changed. They have a dull look and lack the metallic luster of the minerals. The agitation froth produced with the quantities of oil which the patent in suit informs you are suitable, does not disclose the presence of any oil. The faint traces of oil which must be there are absolutely invisible and only a careful chemical analysis can show their presence. To the touch the concentrates thus obtained are the same as the ordinary mineral which had never been treated with any oil. I cannot understand why Dr. Byrnes produced these experiments. He only proves that he can produce, with much larger quantities of oil than are considered economical by the patent in suit, a froth, but at the same time he proves that the quantities recommended as economical in the patent in suit are economical. It frequently occurs in patent litigation that a defendant will make an untenable defense by alleging that he produced a result by different quantities, sometimes by much larger quantities, but, of course, such a defense must always fail. It is no defense to use the essence of the invention and produce only a result which increases the cost of production in such an enormous way as the cost would be increased if quantities of oil were used such as described in experiments 2, 3, 4 and 5 of the series described in Defendant's Record, pages 165 and 166. I have stated my views on the Froment patent and on the Froment instructions fully, and I need only repeat once more that there is nothing contained therein which would enable anybody to produce the agitation froth of the patent in suit, and, furthermore, that there is nothing con-

tained therein which might lead an investigator even in the direction of the invention of the patent in suit.

(Pages 684-685):

37 Q. Please now give consideration to the testimony of Dr. Byrnes relative to the patent in suit as appearing in his answer to Q. 4, pages 110 *et seq.* of Defendant's Record, and again at pages 167 *et seq.* of Defendant's Record, making such explanation of your own knowledge of the same subject-matter as may clear up the matters referred to.

A. It is true that the patent in suit makes use of the well-known property of minerals that they have an affinity for oils, whilst the gangue practically repels the oils. It has been stated in this evidence that this fact is as old as at least Heredotus. Anyhow, it was clearly established in Haynes' specification applied for in 1860, and since then a number of attempts have been made to solve the difficult problem of ore concentration by this method. They have all failed, although two of them, namely, Elmore and Cattermole, have been practically used. They disappeared as soon as the new invention which forms the subject-matter of the patent in suit was made. The patent in suit was the final solution of a problem to which, as the number of patents offered by the defendant proves, a great many inventors had applied their ingenuity, their energy and time and labor, and had been unable to accomplish the result. It happens frequently so with great inventions. The results are not obtained suddenly. Very often a large number of years pass by, every year containing a contribution which remains sterile, until finally the right way is found and the world enriched thereby.

(Page 688):

Dr. Byrnes continues his description and refers to a specific example contained in the specification, but he has here overlooked the important statement:

> "The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical."

This statement is of significance. Even at the time when the inventors could have only a comparatively small experience, they found the proportion of oil in quantities of 0.1 per cent. to one hundred parts of ore suitable and economical. In the number of years which have passed since the filing of this specification, this experience has been confirmed, and proves the power of exact and careful observation of the patentees. In the description of this example, the patentees also called attention to the fact that the power of flotation of the froth is mainly due to the inclusion of air bubbles introduced by the agitation.

(Page 689):

In the agitation froth process, the oil, although specifically lighter than water, is present in such small quantities, in quantities which I called before infinitesimal as compared with the quantities of oil used formerly for flotation processes, and infinitesimal as compared with the quantity of mineral which they have to coat, that it scarcely plays any part in the flotation of the minerals.

(Pages 691-692):

It is a suitable place here to give my experience of the working of the patent and to describe such experiments which will be of assistance in showing that the

statements made in the patent are correct. I have seen the process carried out several times in the plant at the works of Minerals Separation, Limited, in London. This plant is capable of treating fifty tons of ore a day of twenty-four hours. It is practically the same as that shown in the drawings "Complainants' Exhibit King John's Court Standard Plant," with the exception that another spitzkasten has been added in front of the agitating box marked 3, so that there are six spitzkasten, instead of five, shown in the drawings, and that the deflector F was not present. I saw on the spitzkasten large quantities of the froth, which I have characterized before, sometimes three or four inches deep. I have also made numerous tests in the slide machine and in the cone mixer or Gabbett, and I have used for these tests different ores and different oils. I usually succeeded with the quantity of oil, namely, 0.1 per cent., which is recommended in the patent as "suitable and economical." In one instance I found the addition of .025 per cent. to .1 per cent., making a total of .125 per cent., was necessary for the production of a good froth. This was with palm oil. With linseed oil I got the best result with .2 per cent.

(Pages 708-709):

The last part of Dr. Byrnes' answer referred to, pages 173, 174 of Defendant's Record, states that the patent in suit is very vague as to the details of the process and as to the proportions of oil and acid to be employed. He says here again what he has also stated on page 180 of Defendant's Record, namely, that the patent specifies the proportion of oil and acid,

> "say from 0.02 per cent. to 0.5 per cent. on the weight of the ore,"

and continues later on—

> "Later the description states, in the most gen-

eral terms, that the proportion may be 'under 0.1 per cent. of the ore.' "

He omits deliberately to state the end of the sentence, closing the quoted part from the patent in suit (page 1, lines 100, 101):

"may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical."

This is a distinct statement, and sufficient guidance for any metallurgist to work upon.

(Pages 709-710):

They (the patentees) give as an example the well-known Broken Hill ore, with which they appear to have been very familiar. They inform the world what they consider the limits of their proportions, and they add that in their experience 0.1 per cent. of oil of the amount of ore has been found "suitable and economical." Surely one cannot demand more, and even a metallurgist of very low qualifications cannot fail to determine with the greatest ease what quantities will give him the desired results.

(Pages 734-735):

There is a wide difference between the coating with oil as disclosed in patents No. 788,247 and No. 777,274, and the coating with oil as disclosed in the patent in suit, and it is quite apparent from the quantities which are described as useful in the two different sets of patents. In the Cattermole patents No. 788,247 and No. 777,274, the quantity is clearly alike with the quantity disclosed in Cattermole patent No. 777,273, and that is 4 to 6 per cent. on the minerals (1.4 to 2 per cent. on the ore), with a warning that the process is not to be used with lean ores. In the patent in suit the quantity found suitable is .1 per cent. Expressed in pounds per

short ton, Cattermole requires 28 to 40 lbs. as a useful quantity, and the patent in suit describes 2 lbs. as a useful quantity.

(Page 749):

In none of these alleged anticipations is the phenomenon or the process of the patent in suit disclosed. In none of these alleged anticipations is there any suggestion which would lead anybody towards the process or the phenomenon of the patent in suit. In none of these alleged anticipations is there any suggestion that by beating in air a froth could be produced consisting of air bubbles densely covered with minerals and carrying practically the whole mineral contents of the ore. In none of these alleged anticipations is there any suggestion that a quantity of oil could be used so small that it disappeared and could only be detected on the concentrates, by chemical methods.

(Pages 783-784):

90 X-Q. Did this agitation froth which you secured contain bubbles of gas covered with an envelope of sulphides?

A. This agitation froth contained bubbles of gas covered with an envelope of sulphides, and it differed in this respect from the magma obtained according to the Froment test tube example. It was perfectly stable, the minerals were brilliant and had a metallic luster. When it once appeared on the surface, it stayed, and when sunk by force it could be reobtained by vigorous agitation. The Froment magma is more like an oily layer containing bubbles of carbonic acid, which are enclosed in oil in which the minerals are embedded. The magma is not lasting. In the agitation froth, no oil can be discovered. If it is put on blotting paper, it dries, but it retains its shape. If the Froment magma

is put on blotting paper the oil soaks into the blotting paper and leaves a large spot, and the bubbles collapse. In the agitation froth, the film enclosing the air is water, which is protected and strengthened by a dense layer of the minerals. In the magma there is a layer of oil, which contains carbonic acid bubbles, and the film enclosing them is oil covered with minerals. The difference between the two is that the agitation froth is lasting, whilst the bubbles contained in the magma are not.

(Pages 795-797):

117 X-Q. In your answer to my question numbered 103, you have stated how you would proceed if it were your intention to produce what you term "an agitation-froth." Did you ever perform any operation following the lines laid down by you in your answer to that question, except that you used an amount of either cotton-seed oil, olive oil, oleic acid, or other suitable oil, equal to more than one per cent. by weight of the ore operated on, and particularly did you ever, in such an operation, use an amount of a suitable oil equal to 3.6 per cent. by weight of the ore, this latter proportion of oil being that used by Dr. Byrnes in the experiments described by him beginning with the paragraph at the bottom of page 165 of Defendant's printed Record and extending through the first two paragraphs on page 166?

A. I have made no such test tube experiments, but I see that your question is not limited to test tube experiments. I have made a number of experiments in which I used more than one per cent. of oil in proportion to the quantity of ore used. They refer to the alleged anticipations which have been produced by the defendant. I find one note in which I say "50 grams of ore, 150 cc of water, ½ gram of sulphuric acid, 1½

grams of oleic acid, all at bottom." This experiment was made on 22nd of July, long before I had read the evidence of Dr. Byrnes.

I have another experiment here in which I used 400 grams of ore, 1600 grams of water, 4 grams of sulphuric acid and 12 grams of oleic acid. This experiment was carried out in a cone mixer, and the agitation lasted two and a half minutes. The temperature was 44° Centigrade. The remarks are:

> "No froth; granules below sand."

This experiment was made on the 23rd of July, long before I had any knowledge of Dr. Byrnes' evidence.

On the same day I made an experiment with the same quantities, except the quantity of oleic acid. That was 20 grams. The temperature was 40° Centigrade. The remarks are:

> "No froth; granules heavy, much heavier than sand; granules formed bigger during agitation."

This latter part must mean during continued agitation.

Then I have an experiment on the same day. The quantities the same as before, with the exception of the quantity of oleic acid. That was increased to 40 grams and the remarks underneath are:

> "Granules getting bigger and heavier; thin layer of oil on surface."

Where I used 50 grams of ore and 1½ grams of oleic acid, the proportion was 3 per cent. of oil as compared with the ore.

Where I used 400 grams of ore and 12 grams of oleic acid, the proportion was 3 per cent. of oleic acid.

Where I used 400 grams of ore and 20 grams of oleic acid, the proportion was 5 per cent. of oleic acid.

Where I used 400 grams of ore and 40 grams of oleic acid, the proportion was 10 per cent. of oleic acid.

These examples could be continued, but I should

like to specifically mention the experiments made with special reference to the Cattermole patent. The quantities of oil used therein are within the limits of your question. The experiments described were made by me only for the purpose of study.

(Page 800):

126 X-Q. In any of the operations which you performed following the lines laid down by you in your answer to X-Q. 103, did you obtain any flotation of the metalliferous mineral when using more than one per cent. by weight of oil, that is, one per cent. of the weight of the ore?

A. In all experiments along the line which I described in answer to X-Q. 103, the bulk of the minerals was always at the bottom. There may have been at times a small part on the surface as skin flotation, and there may have been at times a thin layer of oil on the surface. I am excluding from this answer experiments made with such quantities of oil which resulted partially in oil buoyancy flotation and partly in the collection of the minerals at the bottom of the vessel. But, I should say broadly that the results which I have fully described are the true expression of my experimental experience.

127 X-Q. Is your answer to the preceding question limited to those operations in which you used an amount of oil equal to more than one per cent. by weight of the ore; or does the answer apply to operations including all the quantities of oil which you have used in practicing according to the procedure set forth in your answer to X-Q. 103?

A. My answer applies to such experiments which started at the lower limit with the Cattermole proportions of oil, namely, about 1.4 per cent. of oil upon the ore.

(Page 802):

130 X-Q. I understand from your answer to X-Qs. 126 and 127 that you have never, in your operations along the lines laid down in your answer to X-Q. 103, obtained any floating mineral-bearing froth when using an amount of oil or other selective agent amounting to more than one per cent. by weight of the ore. In order that there may be no misunderstanding, will you state whether I have understood you rightly?

A. That is my recollection.

(Pages 828-829):

188 X-Q. Do not the experiments performed by Dr. Byrnes, regardless of whether you consider them Froment operations or not, show that a froth can be produced using quantities of oil largely in excess of the quantities specified in the patent in suit?

A. I have myself not made such an experiment, and I am not speaking from personal experience. I am of opinion, as I stated, that if a froth is produced with quantities of oil such as are used in four of the five experiments, it must lack some of the characteristics of the agitation froth; that is, for instance, it would not show the metallic luster and would be oily. Dr. Byrnes says he has produced a froth with a large quantity of oil. If it is produced, it is not produced by the Froment process, but by the process of the patent in suit. A froth such as can result from the quantities of oil used in four of the experiments would be valueless for the reason of its great expense.

(Pages 836-837):

200 X-Q. In commenting, in your answer to Q. 34 upon Dr. Byrnes' experiment described in the paragraph beginning at the bottom of page 165 of Defend-

ant's Record, you state that "the concentrates produced on the surface of the liquid are both in appearance and character entirely different from the agitation froth of the patent in suit," and you further state that "the oily character of the minerals is clearly visible to the naked eye." As you have stated that you did not repeat Dr. Byrnes' experiments in the slide machine, will you kindly state what experience you base your quoted statements upon?

A. I have seen many times concentrates produced even with much smaller quantities of oil than used by Dr. Byrnes, and in each case I found the appearance greatly different from the appearance of the agitation froth. Even quantities as small as 1.5 per cent. alter the look of the mineral particles.

Dr. Charles F. Chandler, Recalled.

(T. R., Vol. III, page 882):

Cattermole Patent No. 777,273, of December 13, 1904. This is the granulation patent and constitutes the next real step forward in the art after the Elmore patents.

A great reduction is made in oil quantities from those used in the Elmore process. Instead of 6,000 lbs. of oil to the ton of ore, we have a recommended proportion of from four to six per cent. of the weight of the metalliferous mineral present in the ore, which, with Broken Hill crude ore, which contains about 50 per cent. of mineral, would be 2 to 3 per cent. on the ore. With Broken Hill tailings containing about 30 per cent. of mineral, this recommended percentage would be 1.2 to 1.8 per cent. on the tailings, which in this instance would be the ore.

(Pages 896-898):

Froment Description and Drawings of 1903. Here we have for the first time a description by Froment of a process and apparatus capable of dealing with ore in practical quantities. . . .

The de-slimed ore is fed into the mixing apparatus, which he calls a centrifugal mixing apparatus containing two stirring devices worked in oppositie directions and making about 300 revolutions per minute.

Then the mixer is charged with ore and water, about 1% of carbonate of lime, maximum 2% in difficult cases, and about 1 to 1½% of mineral engine oil are added. The mixing apparatus is then allowed to work for ten minutes, the chief point being that all the sulphide grains shall come into thorough contact with the oil.

This is a clear statement of the necessity of thoroughly mixing the oil and ore. . . .

The process as thus described is for a lean ore. If the ore contained more than 5% of metallic matter, Froment says it would be necessary to use more oil, and recommends 2% for ore containing up to 15% of metal, indicating this as the upper limit for copper ores in the Latin countries, while for lead ores, which are richer, Froment recommends 2½% of oil for an ore containing 30% of metal, 3% of oil for 40% of metal, and 3½% of oil for 50% of metal.

(Pages 908-909):

125 Q. Having now considered the prior art, both as set forth by the defendant and as supplemented in complainants' rebuttal testimony, what have you to say as to the novelty of the invention disclosed in the patent in suit?

A. The process of the patent in suit is a new process not disclosed in any or all of the documents referred to by complainants or defendant as prior documents. It was to me a most surprising process. After studying all these prior documents, my surprise is not diminished that such a process is possible. There is nothing like it disclosed in the prior art and the failures of other inventors tended to discourage rather than to encourage the hope that the economical concentration of ores was capable of realization in a process utilizing the affinity of oil for metallic substances.

Of all the prior processes, the nearest approach to the process of the patent in suit was the Cattermole granulation process. Here there was agitation of an ore pulp with an amount of oil as small as 1½% of the ore, or 30 lbs. to the short ton, and with reasonably small quantities of acid, utilized only for its physical action in increasing the preference of the oil for the mineral.

(Pages 910-911):

The simplicity of the process of the patent in suit is as remarkable as its economy. For continuous operation only two pieces of apparatus are required, an agitator for briskly agitating the ore pulp and beating air into it, and a spitzkasten or separator in which the froth may rise to the surface and float off into a launder. The oil consumption is one one-thousandth part of the weight of the ore treated, equal to 0.1%, equal to 2 lbs. to the short ton of ore. The acid consumption, since no chemical action is required or desired, is extremely small. Some heating is usually required, but this is not carried to such a point as to be a serious item of expense.

The remarkable thing about the froth produced in this process is its permanency. The bubbles of air, with water films, are thickly coated with mineral particles and appear to be armored by these metallic particles. The froth piles up thickly and carries the great weight of the mineral particles, which are the heaviest particles of the ore. The oil has entirely disappeared from sight and sense. It cannot be seen and it cannot be felt, and the particles of mineral are just as bright as though there was no oil upon them at all.

(Pages 918-919):

136 X-Q. Referring to patent No. 788,247, what is your interpretation of the function performed by the oil which is used, that is, the oil which results from the decomposition of the soap?

A. I understand that it coats the particles of minerals with an oily film, which repels water, while the particles of gangue, being wetted with water, do not receive a coating of oily matter from the soap. The consequence is, if these particles of oiled mineral get to the surface they float there by surface tension.

137 X-Q. You stated in the first deposition which you gave in this suit, that, in the processes of Cattermole patents 777,273 and 777,274, "so large an amount of oily matter is employed as to agglomerate together the metalliferous particles contained in the ore into granules or pellets." Is it your understanding that the amount of oil used in Cattermole, Sulman & Picard patent No. 788,247 is also of such a quantity as to cause the metalliferous particles to agglomerate together?

A. There is no statement in the specification of the quantity of soap added or the quantity of fatty acid to liberate it, nor is there any suggestion of agitation by which oiled particles of ore might be agglomerated into granules. After the oiling of the particles has been accomplished, the patentees merely suggest that these oiled particles may be brought to the surface by gas bubbles or brought to the surface by added particles of wood or saw-dust previously coated with fatty acids by means of the soap treatment.

138 X-Q. Do you find the specification of Cattermole, Sulman & Picard patent No. 788,247 to contain sufficiently explicit directions to enable one to apply the process there set forth, and particularly that species of the process which includes, after oiling, flotation by gas bubbles?

A. The specification is certainly not very explicit. In the first place, it mentions a variety of substances to be added to the water, as soaps or similar compounds, such as cresols, phenols, resinous bodies, etc., and gives no idea of the preferable material and no idea of the proper quantities to be employed. There is a wide difference in the different materials which are mentioned as equivalent to each other; for example, an oleic acid soap and a phenol compound. Phenol when set free from its alkaline compound by an acid is quite soluble

in water, while the true fatty acids set free from soap are practically insoluble in water, or nearly so. It would seem to me that very different quantities of these different substances would have to be selected according to their respective properties. It seems to me that it would be necessary to conduct a number of experiments to successfully practice the process, even if that be possible, and I have my doubts whether the process is practicable at all.

A. Howard Higgins, Recalled.

(T. R., Vol. III, pages 929-930):

31 Q. Have you made tests in a modern continuously-operating plant for the production of the agitation froth, using cottonseed oil in the proportions used by Dr. Byrnes in his second test in the slide machine alleged to be in operation of the Froment British patent described by him on pages 165 and 166? If so, please give the details of this test.

A. Yes, I have made tests at Butte, Montana, in a plant substantially the same as that shown in the drawings "Complainants' Exhibit King John's Court Standard Plant," with the exception that there were six spitzkasten instead of five. The apparatus is a small one, having a capacity of 10 lbs. of ore per minute. The ore used was from the Elm Orlu mine, which is adjacent to the Black Rock mine of the Butte & Superior Copper Company. With the exception of the presence of some clay in the ore, it was practically identical with the Black Rock ore. After being crushed to 80 mesh, it was fed to the plant at the rate of 10 lbs. per minute, sulphuric acid and cottonseed oil being fed in the proportions used by Dr. Byrnes in his second test. In about three minutes the plant had settled into a permanent condition. The float on the first spitzkasten was copious, being about one inch to an inch and half deep, and though oily in appearance when closely examined, did not differ in appearance from the usual agitation froth at a distance of a few feet. These floats were exceedingly dense and occasionally fell down in large masses. The tailings contained some granules, and did not indicate a satisfactory

recovery. Samples were taken of these products and assayed.

Original ore,	Zinc 20.41%	Insolubles 59.95%
Concentrates,	" 47.54%	" 11.82%
Tailings,	" 12.94%	" 77.24%

giving a recovery of 50% of the zinc in the concentrates.

The small plant that I used is nominally a five ton plant, although its maximum capacity is seven tons per day. This plant is not intended for commercial use in treating zinc ores, being only a testing plant. The percentage of oil used in the test was 3.6 on the ore, corresponding to 20cc. of cottonseed oil used by Dr. Byrnes.

George A. Chapman, Recalled.

(T. R., Vol. III, pages 934-936):

249 Q. Have you made tests in a modern, continuously operating plant for the production of the agitation froth, using cottonseed oil in the proportions used by Dr. Byrnes, in his second test in the slide machine alleged to be an operation of the Froment British patent and described by him on pages 165 and 166 of Defendant's Record? If so, please give the details of this test or tests.

A. I made a test in the London Standard plant. This is the same plant described by Dr. Liebmann in his testimony, page 499 of Complainants' Record, containing eight agitators and six flotation boxes, and it was used in the same conditions as when Dr. Liebmann used it in his London experiments. This is known as a fifty ton plant and could be worked at that capacity at a mine, but it is used for testing purposes only and never run to its full capacity.

The ore that I used was Broken Hill tailings, containing about 18% of zinc and about 5% of lead. This ore was crushed to pass through an 80 mesh screen. The plant was operated for an hour and 1680 lbs. of ore were fed in during this period. Cottonseed oil was used in the proportion of 3.6% of oil on the weight of the ore, and the acid consumption was 0.37% on the weight of the ore (1 cc. is 1.8 grams, which is 0.368% of 492 grams of ore). The temperature of the water was maintained at 70° Fahrenheit.

An oily float was obtained, some of which was carried below the surface of the water. I made adjustments so as to carry this float over; certainly more than 30% of it was carried below the surface of the water. There were large, clean, oil-film bubbles in it and it did not look

at all to me like an agitation froth such as is obtained under normal and economical conditions of oil consumption. The float looked oily, and it was oily to the touch, whereas the normal agitation froth does not show the presence of oil nor can you feel that there is any oil in it.

The tailings were oily and dirty and contained incipient granules. I took some of these tailings and rolled them in a Gabbett without baffles and obtained good granules.

I separated the concentrates which overflowed from the six flotation boxes and had them separately assayed, and also had the tailings assayed.

(Pages 937-938):

After I had made these two tests, it was suggested to me by our patent agent, Mr. Ballantyne, that I would more nearly parallel Dr. Byrnes' tests by having less agitation. Dr. Byrnes agitated in a slide machine for thirty seconds for his first agitation and from ten to twenty seconds each for his subsequent agitation. We usually agitate one and a half to two minutes for the first agitation in the slide machine, and half a minute to one minute for subsequent agitations. To repeat this condition of under agitation, I made another test with proportions of all material, temperature and time the same as in my experiment No. 1, but using only six agitators, one agitator for each of the six flotation boxes. The results were a slight improvement on the results in test No. 1. The floating material was the same and the tailings contained incipient granules which I granulated as I have described before.

(Page 939):

250 Q. Have you also made a test in the same plant using oleic acid in the proportion of 1.8% on the ore, and the proportion of sulphuric acid given by Dr. Byrnes

and used by you in your experiments 1 and 3 with cottonseed oil? If so, please describe the experiment.

A. I made this test using a very good oleic acid, purer than the ordinary red oil of commerce. The floats were very bulky and contained a very high proportion of gangue and very little enrichment of the crude ore took place. The procedure was altogether wasteful, and the result of no commercial value at all. If the agitation froth process, when properly used, gave any such results as this, it would never have been adopted for practical use. The float obtained was oily in appearance and oily to the touch, but not as oily as in the other tests where I had used cottonseed oil and had used twice as much oil.

(Page 944):

255 Q. Does normal agitation froth operation make a plant greasy, as did the tests you have described?

A. No. The oil disappears. The dirt in the plant is never greasy.

Henry L. Sulman.

(T. R., Vol. IV, page 1604):

Q. 6. I understand from your answer to question 4 that about July, 1903, you had learned of the intentional use of a gas with an oily substance to produce flotation. If I am correct in this will you describe the process so referred to?

A. A pulp of the ore containing the mineral which it was desired to separate was mixed with a small quantity of oil insufficient to float the mineral by the buoyancy of the oil alone and mixed sufficiently to ensure the attachment of small quantities of oil to the mineral. A gas was then liberated in or generated in the pulp so prepared, and it was found that such gas had a tendency to attach itself to the oiled particles. If air were used this was liberated by blowing a stream of bubbles through the mixture in several ways, and if a gas other than air were employed this was generated in the liquor by chemical reactions or by electrolysis.

(Page 1605):

Q. 8. By whom was this process originated?

A. By Mr. Picard and myself, and at a later date Mr. Cattermole co-operated with us in a further development.

Q. 9. Was this the first process of which you learned in which the joint action of oily matter and a gas were utilized for the purpose of floating part of the constituents of an ore?

A. That is my memory of the first time that I learned of the essential use of a gas towards flotation of oiled mineral, although I subsequently found this knowledge had been antedated by Mr. Froment.

Q. 10. And about when, if you remember, did you learn that Mr. Froment had practiced such a process?

A. I learned of the Froment process from the abstract of a patent which was published in the Journal of the Society of Chemical Industry which I saw in August, 1903.

(Page 1606):

Q. 13. Will you describe somewhat in detail the procedure followed in operating the Froment process with bottles, test tubes, and the larger vessels to which you have referred?

A. We made our experiments by following the instructions given in Froment's British specification. We added the ore to a liquid, water, to form a pulp (freely flowing pulp), and also added to this a substance capable of being decomposed by a dilute acid for the purpose of generating a gas, such, for example, as calcite, whiting, or carbonate of soda. A quantity of oily matter sufficient to form a thin layer was then added upon the surface of the pulp, and the whole was then well mixed. A small quantity of acid was then added to the mixture with suitable gentle stirring to bring the acid and the gas-producing substance into contact, and thereupon the oiled mineral was floated to the surface by the bubbles of the generated gas.

(Pages 1607-1608):

Q. 17. Referring to your description of your procedure in operating the Froment process, you have stated that you gently stirred the mixture to bring the acid and the gas-producing substance into contact. Is stirring or agitation necessary in that process for any other purpose than to bring the acid into contact with the gas-producing substance?

A. Agitation in my experience of the Froment process should be given in two stages. Sufficient agitation firstly

to get the oil into efficient contact with the mineral to be subsequently floated. This first agitation is not responsible for the production of the float material required. The second agitation is for the purpose of effecting the due contact and uniform contact of acid with the decomposable substance and much less agitation is required and in my experience is necessary for the second purpose, having regard to the nature of the float material produced.

Q. 18. In all oil flotation processes sufficient agitation is necessary, is it not, to distribute the oil in such a manner that it will come into contact with the particles for which it has an affinity?

A. The first requisite of any oil concentration process is to obtain efficient contact between the oil and the mineral and suitable methods must be employed to effect this. Where the oil is in large relative quantity to the mineral violent agitation is unnecessary and may be very harmful. With decreasing proportions of oil more vigorous agitation or mixing is necessary to ensure such efficient contact of oil with the mineral particles. The agitation may therefore be said to be roughly proportioned to the work to be done in bringing about contact between large or small quantities of oil in regard to the mineral.

(Pages 1612-1615):

Q. 32. When you for the first time saw a process operated according to the United States patent 835,120 in suit, who was present and who actually conducted the operation?

A. Mr. Ballot was present and was supervising the experiment which was being performed by Mr. H. A. Higgins, who was working under our joint direction.

Q. 33. What led to your presence and that of Mr. Ballot upon this occasion?

A. At some date a week or two prior to our discovery of the air agitation froth, Mr. Ballot, Mr. Picard, and myself had been in close consultation as to a number of factors which we considered required finally investigating and quantifying. They concerned mainly the operation of the Cattermole process, but also had in view the clearing up of a number of loose-end observations noticed in previous developments of oil concentration work. Mr. Ballot, Mr. Picard and myself found it necessary to draw up a schedule of such factors as we considered required investigation, and we instructed the experimental staff at Aldermanbury to carry these out; the carrying out of these final investigations was done under the immediate supervision of one or other of us throughout the whole of them. The factors to be investigated were as follows: In a report dated March 3, 1905, made by Sulman & Picard and addressed to John Ballot is recorded the work which the whole three of us were doing then, and this report is not so much for the information of Mr. John Ballot as the putting on record of work which he and we had jointly done, for purposes of reference afterwards. In it we say on page 2:

> "We are in full agreement with the rest of Mr. Higgins' observations and may summarize the work now being done at Aldermanbury Avenue as the determination of the following factors: —
>
> "1. Influence of acidity on granulation.
>
> "2. Influence of temperature on ditto.
>
> "3. Influence of speed of gabbet agitation on granulation.
>
> "4. Influence of ratio of ore to liquor on granulation.
>
> "5. Influence of metallic salts on granulation.
>
> "6. Influence of the size of particles and of the influence of slimes on granulation.
>
> "7. Influence of the amount of oil on granulation.
>
> "The above factors are being determined on—
>
> "(a) Oleic acid.
>
> "(b) Residuum oils.

"Mr. Higgins' present report is therefore the first instalment of the above scheme of trials."

Mr. Higgins was sending in, in like fashion, to Mr. Ballot the daily records of these trials proceeding under the joint supervision of the three of us. It was in the carrying out of the latter factor, namely, the amount of oil in its effect upon granulation that in reducing the amount used beyond all previous quantities in regard to the mineral, that we found granulation to decrease or even cease when a certain limit was reached, and that coincidentally a mineral froth began to take its place. When we decreased the amount of oil to about .6 per cent. upon the ore, granulation had ceased to appear and a very considerable proportion of mineral was found to float in the surface as a thick froth. We still further decreased the amount of oil until we found that with .2 to .1 per cent. of oil on the ore practically the whole of the mineral came to the surface as a thick blackish matted froth.

(Pages 1615-1616):

Q. 34. Can you remember at this date the substance of Mr. Higgins' report which you refer to in the document identified as "Sulman and Picard Report March 3, 1905," or, if you can, will you produce that report?

A. This report has been handed to me by counsel, and before referring to it I will state that at this date the discovery of the agitation froth had not been made. Mr. Higgins' report therefore deals with some of the prior factors of granulation set out by us in our schedule of items to be investigated. Mr. Higgins' report is dated March 2, 1905, and is headed "Report on the Conditions of Granulation." It deals in detail with the results of (1) the influence of acidity in granulation, (2) upon the influence of heat on granulation, setting forth in detail

the experiments which he tried under the directions he received (3) with the influence of the thickness of the pulp, and (4) with the influence of peripheral velocity of cone. On the last page of his report he notes that experiments are also to be carried out on the influence of the quantity of oil present in order to complete the information regarding granulation.

(Pages 1616-1617):

Q. 36. As I understand you, to put the matter briefly, Mr. Higgins was instructed to ascertain the effect upon granulation of varying the various factors of the Cattermole process and that while carrying out these instructions he found that with the quantity of oil too small to properly granulate the concentrates, flotation resulted. Is this the correct understanding?

A. Mr. Higgins was a capable experimenter fully qualified to carry out intelligently all instructions given to him. The instructions given in regard to each of the factors was that they were to be investigated to their full limit in order to quantify and also to explore the limits of application of the Cattermole process. These experiments were carried out by him in the constant presence, although not the continuous presence, of all of the patentees, Mr. Ballot, Mr. Picard and myself, and he recorded the results of such experiments.

(Pages 1618-1620):

Q. 40. Were either yourself, Mr. Picard or Mr. Ballot present at the time Mr. Higgins first experimented, in pursuance of the instructions set forth at the bottom of page 2 of the Report of March 3, 1905, with an amount of oil falling within the limits designated in United States patent 835,120 in suit?

A. Mr. Picard and I were not present at the first dis-

covery that by dropping the oil quantity below the last granulation limit the agitation froth was produced, but I have reason to believe that Mr. Ballot was present, as he came round to my office, and at once called me to go with him to see what had been the result of such oil diminution, and I went with him at once. The experiment was again carried out in my presence. I understood that it had been found to occur only a comparatively short time before I was called to see the result of the carrying out of this No. 7 instruction to its further limit.

Q. 41. I take it that this was not the first information you had ever had to the effect that froth flotation could be secured by the use of a very minute quantity of oil; am I right in this?

A. In regard to the formation of a froth of this nature, which is so specific in its character and in the presence of an amount of oil so relatively exceedingly minute as in this instance, this was the first time that I had had experience of any such phenomenon. You have used the word "froth" as if this were a term widely applicable to float material produced at a liquor surface, but it has a very wide and loose use, and is frequently very misleading. If by "froth" is meant an assemblage of bubbles at a liquor surface, such bubbles being separated from each other by a contaminated liquor film, the majority of such froths would be useless for any purpose of separating mineral from gangue. Thus, we may have a soap froth which will carry but little mineral or gangue, and will differentiate between neither, we may have a saponine froth which will hold neither mineral nor gangue, and many other froths of the same nature. I have heard the float material produced by the Froment reaction described as a froth, but it is a tender and evanescent assemblage of bubbles of carbon dioxide carrying mineral, and is not comparable in nature or char-

acter with the agitation froth described in the patent in suit. For a froth to be effective at ordinary ranges of temperature between, say, air temperature and well below boiling, the froth must be coherent and permanent for a considerable time. Such froths are typified in my experience only by the agitation froths produced by vigorously agitating an ore pulp with very minute amount of oil, that is to say, less than one per cent. on the ore in the presence of air. Therefore, in answer to your question, this was the first occasion upon which I had seen a heavy, thick, matted froth, which was permanent and coherent, produced.

(Page 1622):

Q. 44. In the operations which you referred to in your answers to questions 6 to 8, these operations having been originated by yourself and Mr. Picard, what kind of an apparatus did you use?

A. The apparatus we used was of laboratory type in all cases, that is to say the vessels of various shapes were of glass, and the tubes and connections were of glass or India rubber; cylinders, beakers, bottles, basins, plaques, and so on. In one or two instances small adjuncts were made of tin or tinned iron.

(Page 1623):

Q. 46. What degree of success did you meet with in operating this process with the apparatus you describe?

A. Our success in these operations was of very imperfect nature, and our specification rather represented a pious hope that we should ultimately attain success on these lines. The floats obtained were in general thin and tender, and were mainly of the nature of the surface-tension effects at a water surface. We tried a great many experiments on various lines indicated, but in no

case were we able to attain to a persistent and coherent froth. After a considerable amount of time and experiments we discontinued our efforts in this direction, owing to the small degree of success experienced and from the apparent improbability of such processes developing into a commercial method for mineral separation from gangue.

Q. 47. About what quantity of oil relative to ore did you use in these operations?

A. So far as I remember, the quantities used of oily matter were always substantial, that is to say, they would always be in excess of one per cent. upon the ore taken. At that time we had no knowledge of the effective use of quantities of oil below the proportions employed by Cattermole, and regarded these Cattermole quantities as being likely to be required in flotation work of the nature we were experimenting upon.

(Page 1635):

Q. 77. Did the flotation of mineral in the form of a film ever occur at any time other than at the beginning of the operation of the apparatus when the froth was first beginning to spread over the water surface, and at the end of the operation, when the froth was leaving the water surface?

A. In my experience at such times, and also by temporary interference with the other conditions which I have mentioned, such as irregularity in supply of ore or oil, or considerable fluctuations in temperature. Given the proper conditions ascertained in regard to each plant and ore operated upon, a production of a coherent froth was continuous whilst such conditions were maintained.

(Page 1647):

Q. 107. In operating with the process which patent 835,120 in suit purports to set forth, did you devise any means for maintaining the amount of acid and oil relative to ore set forth in that patent when operating upon the pulp flowing at a varying rate, and containing a varying percentage of ore to water?

A. In the plant devised to give effect to the process described in the patent in suit at the experimental works of Minerals Separation there were no difficulties in obtaining uniformity of pulp, of ore supply, and, therefore, of ratio of ore to liquor. In these cases, owing to the fact of the location of plant in London, the ore was dry crushed, and hence could be measured with fair accuracy and proportioned to water in such a manner as to insure uniformity.

(Page 1649):

Q. 110. Will you kindly, for the purpose of making our terminology clear, distinguish between what I think has been referred to by us as "froth flotation" and "film flotation"?

A. We have generally confined ourselves in speaking of froth to the specific type of froth produced by the process described in the patent in suit. This froth consists of an assemblage of bubbles of air, with some traces, perhaps, of other gases, but mainly air, the bubbles being of varying sizes from exceedingly minute ones to quite large bubbles. The liquor surfaces of these bubbles are highly contaminated and associated with the slightly oiled mineral.

(Page 1654):

Q. 119. As I understand you, to state it briefly, the operator of the process, in order to maintain the proportions of oil and acid to ore, as set forth in the pat-

ent in suit, naturally must be informed as to the amount of ore which he is treating, in order to maintain the proportions referred to; am I right?

A. It is, of course, well that he should be informed of this, or should take such steps himself as would enable him to apply the agitation froth process described in suit, under these or any similar abnormal conditions. The adjustment of the oil, even under such abnormal conditions, is, however, very easily effected, because the phenomenon of the agitation froth production is in itself an indication of the right amount of oil to employ.

(Pages 1654-1655):

Q. 120. Then, it might be, that an operator following what you have termed the synthetic mode of regulation might not know whether he was adding oil or acid within the proportions set forth in the patent in suit?

A. It might be so, for the space of a minute or two as to the acidity, this can be determined instantly by means of Litmus paper, or other suitable indicator, it only being necessary to have a slight degree of acidity present in the pulp. As to oil, the proportions specified in the patent do not need extremely fine adjustment. When the generally minute quantities of oil to ore are considered, which amount in practice, roughly, to about two pounds per ton of ore in a great number of cases, or perhaps somewhat less or more, conditions of ore supply may fluctuate to some extent without greatly affecting the result. If these fluctuations in supply are excessive then the operator would naturally make such further slight adjustment of his oil addition as would meet the altered circumstances.

(Pages 1656-1657):

Q. 123. You have stated in answer to question No. 119 that if it were not convenient to quantify the ore supplied from time to time it would be quite easy and effective to slightly vary the oil additions to the incoming pulps in order to produce the maximum agitation froth formation. In operating according to this method the operator would be guided, would he not, by the results secured rather than by the maintenance of any known quantitative relations between the different materials?

A. That is what I meant, the result to be obtained being the production of the specific agitation froth required.

(Pages 1662-1663):

Q. 143. You have referred to the fact that you and Mr. Picard were developing or working upon a flotation process at the time you first learned of the existence of the Froment process. Is the process which you and Mr. Picard were then occupied upon the one set forth in United States patent 793,808, granted to yourself and Mr. Picard July 4, 1905?

A. That is the only flotation patent that Mr. Picard and I worked at alone, but there was another flotation process about the same time in which we were also concerned with Mr. Cattermole, United States patent No. 788,247.

(Pages 1678-1680):

R-D. Q. 182. Whenever flotation concentration takes place in a pulp to which too little oil to float the mineral by the oil buoyancy has been added, and the pulp has been agitated with the result of raising all of the oiled mineral to the surface as a scum or froth, would

you assume that air beaten in by the agitation had caused or assisted the flotation?

A. This is a very wide question, and would apparently include all quantities of oil below the effective bulk oil limits down to the proportions of oil used in the patent in suit. All sorts of phenomena would take place according to the amount of oil employed and degree of agitation given. Some oil entrapping mineral with entangled air bubbles might result, and in such cases the air would aid oil buoyancy effects, just as corks caught in a fishing net might enable the latter to float. According to the extent or deficiency of oil, intermediate phenomena would take place, such as the production of "mushes" or of sunken material, but to the extent that oiled material was floated, entangled air bubbles would naturally help to this extent.

R-D. Q. 183. Assuming that flotation concentration has taken place in a pulp to which an amount of oil equal to two per cent. by weight of the ore has been added, and the pulp has been agitated, thus producing the flotation, would it be your opinion that air beaten in by the agitation had caused or materially assisted in producing such flotation?

A. My experience of such conditions as you have named, and with the degree of agitation that I have been accustomed to give, is that granulation would mainly result, and it is not my experience that effective flotation would ensue if the pulp were then brought to rest.

R-D. Q. 184. Is the degree of agitation, which you have referred to in your last answer, some particular degree or duration of agitation?

A. It is of the necessary degree and duration required to bring such quantity of oil into effective contact with the mineral particles present in the pulp.

R-D. Q. 185. Suppose we assume, as set forth in question 183, that under the conditions there set forth flotation is produced, contrary to your experience though it may be, then would it be your opinion that air beaten in by the agitation had caused or materially assisted as an essential factor in producing the flotation?

A. You are asking me to assume something that I have no experience of, all my experiments in such directions being to the contrary effect, namely, that when a pulp so agitated were brought to rest, sinking of the mineral, and not flotation, would result. Indeed, this amount of oil, in my experience, would generally fall within the Cattermole range, and it is only when the oil falls below one per cent. on the ore, and practically to about .5 per cent. upon the ore in most cases, that flotation by such means take place.

Hugh Fitzalis Kirkpatrick-Picard.

(T. R., Vol. IV, page 1682):

Q. 2. Are you the Hugh Fitzalis Kirkpatrick-Picard named as one of the grantees of the United States letters patent No. 835,120, involved in this suit?

A. I am.

. . . . . .

Q. 4. And when did you first learn of the joint action of oil and a gas concomitantly acting to produce flotation of part of an ore?

A. I learned of its use as an accidental concomitant during our work on the granulation Cattermole process about 1902, wherein some of the granules were occasionally, accidentally, floated by air.

(Page 1683):

Q. 6. And I presume the intentional use of oil and a gas, to which you refer, is to some extent at least set forth and described in United States patent 793,808, granted to Mr. Henry L. Sulman and yourself, July 4, 1905, upon an application filed October 5, 1903, copy of which patent you have before you?

A. Yes, and I see by this date that in one of my previous answers I put my knowledge a little too late. I must have first known of the intentional flotation by means of an oil and a gas early in 1903.

(Page 1684):

Q. 9. In the patent in suit, No. 835,120, in an example of the application of the process the amount of oleic acid used in that instance is specified as from .02 to .5 per cent. on the weight of the ore, the latter quantity being twenty-five times the former. How would an operator practicing the process determine between these wide limits what quantity of oil to use?

A. As a matter of fact, both quantities mentioned are so minute in relation to the proportion of ore that it is hardly right to describe the limits as very wide, but the operator would have no difficulty in determining, if there was any marked difference, which was the best quantity to use, by simply noting whether he was obtaining the specific frothing phenomenon which the patent indicates as being that required.

Q. 10. In other words, the ordinary skill of the operator would lead him to the right amount, as I understand it?

A. Yes, I think an operator after studying this specification, and possessing average technical knowledge, would have no difficulty in so adjusting the amount as to obtain this specific and very definite form of froth.

(Page 1686):

Q. 16. When did you first see operated or demonstrated the process which patent 835,120 in suit purports to describe?

A. About the first week in March, 1905.

. . . . . .

Q. 18. Who conducted this first demonstration which you saw?

A. One of the works staff of Minerals Separation, named Mr. Howard Higgins. Mr. Higgins was at that time engaged under instructions from Mr. Sulman, Mr. Ballot and myself, in investigating, amongst other things, the influence of the quantity of oil on Cattermole granulation, and it was as a result of repeatedly reducing the quantity of oil that eventually we arrived at the production of the specific, permanent and coherent froth which is referred to in the patent in suit.

(Page 1689):

Q. 26. Is it your impression that at the time of this meeting between yourself, Mr. Ballot and Mr. Sulman, it was a new idea to investigate how much oil, acid and what character of agitation should be used in the Cattermole process?

A. My general recollection is that we had been for some time working, more or less in the dark, without understanding the influence of the various factors of the process, and we decided that it would be well to adopt some form of definite line of research, with a view, if possible, of clearing up various points of difficulty in connection with the work.

(Pages 1694-1695):

When the plant was not operating normally and perfectly what happened?

A. You mean specifically with regard to the nature of the concentrates?

Q. 47. Yes.

A. Well, for example, if through any accident the ore feed failed and the oil feed continued, an excess of oil would be supplied and some of the mineral would form rather as granules and sink, or occasionally through any blocking of the delivery pipe a little concentrate might escape, or such concentrates as had already just been delivered might be pulled out rather in the form of film on the spitz box than as froth, but these incidents were quite abnormal, and, generally speaking, I am right in saying that the thick, coherent froth always resulted.

(Page 1700):

Q. 64. In operating the process, which the patent in suit purports to describe, was it your invariable custom to establish a quantitative relation between the

amount of oil and the amount of ore, or did you sometimes proceed simply by using such a quantity of oil as would produce the result you desired, without knowing just the quantitative relation of that amount?

A. In all our tests we endeavored to maintain an approximately definite relationship as to quantity between the amount of ore and the amount of fuel fed into the plant.

(Pages 1700-1701):

Q. 67. Will you state the distinction between the froth or scum which is referred to in the patent in suit and the floating material resulting from operations such as described in United States patent 793,808, granted to yourself and Mr. Sulman on July 4, 1905, as the result of an application filed October 5, 1903?

A. I have already described the froth produced in the patent in suit as being of a very dense, coherent and thick deposit. The floating concentrate obtained in patent 793,808, on the other hand, was of a very feeble and tender character, the very reverse of coherent and persistent, and was of such a nature that extreme care had to be used in its collection. It never reached any appreciable thickness, and was rather of the nature of a thin film.

Q. 68. To what do you attribute the difference between the condition of the floating material produced in accordance with the process of the patent 793,808 and that produced under the process which patent 835,120 purports to disclose?

A. I attribute the difference largely to the greater quantity of oil that was used in working the patent 793,808. The oiled mineral produced under this patent was more of the Cattermole variety, and in our experience air introduced in the manner shown in Figure 1

does not attach itself very readily to these particles of mineral heavily oiled, and though the air did, to a large extent, carry the mineral flocks to the surface, they, the flocks, seemed to sink again with ease in such a manner as to suggest that the air which caused them to float had freed itself from the particles.

(Page 1702):

Q. 70. I take it, then, that you attribute the defective action which you have referred to in the operation of the apparatus of Figure 1 of 793,808, to the use of too much oil?

A. Yes, I think that in large measure accounted for the relative non-success of this process, but, on the other hand, I do not think success would have been obtained with this particular apparatus, even though the quantity of oil had been much reduced.

Q. 71. From which I infer that it is your idea that the success of a froth-flotation process of this kind is dependent, not only upon the use of the proper quantity of oil, but also upon the use of mechanism adapted to bring about other conditions equally necessary to the production of a froth?

A. Of course suitable apparatus must be employed to carry out the object set forth in the patent specification, and we show one method by which these objects may be obtained, but no doubt other forms of appliance would effectively carry out the intention of the patent which is essentially the production of the dense persistent and coherent froth which is the peculiar attribute and essential feature of this invention.

(Pages 1703-1704):

Q. 75. Could you distinguish, by observation, that is, by visual observation, between froths produced by the

use of five-tenths of one per cent., one per cent., one and a half per cent. and two per cent., respectively, of oil?

A. I should have no difficulty, I think, in distinguishing the five-tenths per cent. froth from the two per cent., and probably from the one and a half per cent., but I do not know what is the absolute limit in quantity, which would render it difficult for me to distinguish between them. I may state that by using the upper limit of two per cent. in the apparatus described in the patent in suit I should expect to find an appreciable quantity of granules formed, and this would aid me in forming an opinion as to the amount of oil used.

(Pages 1705-1707):

Q. 79. You have referred to having been called in to witness the operation of forming a froth according to the process which the patent in suit purports to set forth shortly after the discovery of such a mode of procedure was made. Will you state just what you saw on this occasion that was new to you; that is, what was it you regarded as a discovery?

A. What struck me as being new was seeing practically the whole of the mineral which was in the ore charge floating on the top of the liquid in the gabbet whilst at rest, whereas hitherto when using larger quantities of oil I should expect, and, indeed, would have seen the mineral in a more or less granulated condition through the charge, and not floating on the surface, except as to certain accidental flocks. The difference was most marked, and created a very distinct and decided impression on my mind.

Q. 80. I presume that you and your associates proceeded to investigate the causes which had produced this result, and if so, what were the causes to which you attributed it?

A. We already knew from the first test that the cause was due to reducing the quantity of oil much below that hitherto employed, and observation of the froth clearly indicated that the air which had been beaten in played an important and essential part in the production of this new phenomenon. I presume that further investigation work was carried on, but, in my opinion, the invention may be said to have been complete after that first operation.

Q. 81. At the time the process which the patent in suit purports to set forth was first exhibited to you, I take it that you were not then for the first time made cognizant of the possibility of using so small a quantity of oil as had been used, or that you then first became cognizant of the utility of beating air into the pulp; am I right in this?

A. I had no idea prior to this, that by reducing the quantity of oil to the limits which were used in this experiment that such a result would be obtained. I, of course, knew that air would float mineral, previously oiled, but it was not anticipated by me hitherto that this particular result would be obtained if air were beaten in, in the manner in which it was done in making this test. The result of the operation as a whole was an entire revelation to me, and though I knew that work was being carried out on the reduction of the quantity of oil, I never for one moment anticipated in my mind, as being likely to occur, what in fact actually did occur.

John Ballot.

(T. R., Vol. IV, page 1710):

Q. 1. What is your name, age, residence and occupation?

A. John Ballot; age, 52; residence, at Hotel Cecil, Strand, London; my occupation is chairman and managing director of Minerals Separation, Limited, and chairman of Minerals Separation American Syndicate, Limited, the two complainants; place of business, 62 London Wall, London, E. C.

(Pages 1717-1718, part of answer to Q. 18):

Again in my letter to Mr. Courtney of March 10th, 1905, I say:

> "I am pleased to tell you that during the week we have made some very important discoveries which will, I think, almost revolutionize our processes by way of simplifying and cheapening the same. I hope that by next mail the work will be sufficiently far advanced to send you full particulars. Several points have yet to be determined, and the discoveries are of such a nature that we have decided to take our expert and counsel's opinion thereon, with a view to assuring ourselves that we can get good protection under patents. I may mention for your private information that we do not use more than .1 per cent. of oleic acid per ton of ore and although we have not assays out that the recoveries will be very satisfactory."

Again in my letter to Mr. Courtney of March 17th, 1905, I say:

> "*Higgins Report.* Herewith I enclose you copy of Higgins report as received this morning, being a continuation of the one sent you on the 3rd March. By using one per cent. of acid water, or even less than that, three of water to one of ore, and adding .1 per cent. of oleic acid, and heating the circuit to

from 30/32 C and then agitating from 8 to 10 minutes in a single gabbet we find that almost as soon as the cone is stopped in the gabbet from 70 to 80 per cent. of the contained mineral immediately rises to the surface in the form of a scum or froth which floats persistently and remains on the surface of the water for days at a time. . . .''

(Page 1723):

Q. 29. I take it that when Mr. Higgins apprised you of the operations set forth in his report of March 16th, 1905, this was not the first occasion upon which you had been informed of the possibility of using minute quantities of oil in mineral flotation operation; am I correct in this?

A. I had seen the work in progress from about the 1st day of March onwards.

(Page 1724):

Q. 34. And when you saw the work in progress from March 1, 1905, onwards, as referred to by you in your answer to question 29, was this the first occasion upon which you had been informed as to the use in an oil flotation process of the intentional beating in of air for the purpose of promoting flotation?

A. The intentional beating in of air to produce or promote the flotation of froth which was developed by that process was certainly not known until the fact had been actually discovered that by using a very small quantity of oil, say .2 or .1 per cent., and agitating it for a certain time, and then leaving the mixture to stand that the whole froth rose to the surface. By ''discovered'' I mean until the experiments had established the fact that this extraordinary phenomenon was every time reproduced by using the small quantity of oil, violently agitated, and then leaving it to stand, when the mineral rose to the surface in the form of dense froth.

(Pages 1726-1727):

Q. 42. The patent in suit gives a range of quantity for the oleic acid to be used extending from .02 to .5 per cent. in the example set forth in the paragraph beginning at line 70, page 1, the larger quantity being twenty-five times the magnitude of the smaller. In carrying out this process how is the determination to be made as to which of these widely differing quantities is to be used?

A. Starting with the small quantity, say at the rate of one pound per ton of ore, an operator can soon tell by the appearance as to whether the characteristic froth is produced or not. Guided by appearances he would either increase or decrease the quantity of oil or oleic acid until the cauliflower or characterisitc froth was produced, which in itself will be an unfailing index as to whether or not proper conditions have been attained, and he need only then repeat the measurements quantitatively of oil or oleic acid added to his pulp. Of course I assume that the proper agitation and other factors are satisfactory.

(Pages 1728-1729):

Q. 45. In your answer to question 42 and the following questions, I understand that the quantity of oil must be determined experimentally, and that the proper amount of oil is determined by noting the quantity which produces the froth, which you state has certain characteristic qualities. I understand, then, that it is impossible to carry out the process by simply applying the proportions of oil set forth in the patent, and that the final test is not the use of any particular proportion of oil, but the production of the froth; is this correct?

A. The only way to carry out the process is that of applying the proportions of oil set forth in the patent, but to determine, as all practical men will do, which of the proportions, within the range, yield the best result,

the characteristic nature of the froth is always an indicator which will of itself tell an experienced operator when the best conditions have been attained, or, having been attained, whether they are maintained in a continuous running, where variations may occur in the feed to the plant of ore and water or pulp.

(Pages 1738-1739):

Q. 72. How did the degree of agitation imparted to the pulp in the practice of the operations set forth in the patent in suit compare with that used in practicing the Cattermole process which is referred to in the patent in suit?

A. In the Cattermole process, if I remember rightly, there were two degrees of agitation. In the first series of mixers the agitation was fairly violent to disseminate the oil throughout the pulp and to coat the mineral particles. In the second portion of the process a very much slower rolling motion was given to enable the mineral particles to attach themselves to one another and to be rolled into small shot-like granules.

Q. 73. Which of the two kinds of agitation used in the Cattermole process was employed in practicing the operations set forth in the patent in suit?

A. The first, but in a more violent degree, because the quantity of oil being so much smaller than that used in the Cattermole it required more agitation to disseminate it throughout the pulp for the purpose of coating the mineral or being attached to the mineral.

Q. 74. In carrying out the operations of the patent in suit is there any relation between the amount of oil used and the viscosity of the oil?

A. I do not think there is any relation as to the viscosity, provided the oil is in a thin liquid condition so that it can be easily disseminated throughout the pulp.

If an oil like oleic acid were to be solidified or thickened by cold it would naturally be necessary to warm it up to liquefy it.

(Pages 1756-1757):

Q. 120. When did you first see a demonstration of the process which the patent in suit purports to set forth?

A. If by demonstration you mean the phenomenon of the mineral contents rising to the surface in the form of a froth, I first saw that somewhere between the 3rd and 10th of March, 1905, while Mr. Higgins was carrying out the programme of work set him by Sulman, Picard and myself, and especially while he was step by step reducing the percentage of oil used in the experiments.

A. Howard Higgins.

(T. R., Vol. IV, page 1790):

Q. 1. What is your name, age, residence and occupation?

A. Arthur Howard Higgins; 31; "Estrella," Hale Lane, Mill Hill, London, N. W.; metallurgist.

(Page 1791):

Q. 7. And afterwards, I believe, you entered the employ of Minerals Separation, Ltd.?

A. That is so.

(Pages 1793-1794):

Q. 23. In the Cattermole process I presume different results were secured with different oils or fatty matter, or that different oils and fatty matter had to be used in different quantities or in a different way?

A. Yes, different oils and mixtures of oils were used. I believe also in different ways and very slightly different quantities.

Q. 24. About what was the range of quantities of different oils found necessary and advantageous?

A. In general we used 5 per cent. of oil on the mineral, which was increased perhaps to six or seven per cent., and decreased to three or four per cent.

Q. 25. In order to make the record perfectly clear to any one not accustomed to this terminology, please state whether by the word mineral you refer to the entire body of ore being treated, or to the metalliferous constituents which it was desired to separate from the ore?

A. I refer to the metalliferous constituents.

(Pages 1794-1795):

Q. 27. When did you first learn of the use of oils or fatty matter in connection with the flotation of part of the constituents of an ore?

A. As far as I remember, I was instructed in this by Messrs. Sulman & Picard about December, 1903, and January, 1904. This does not include the Elmore buoyancy process.

. . . . . .

Q. 30. What was the occasion of Messrs. Sulman & Picard instructing you in December, 1903, and January, 1904, in the use of oils or fatty matter for flotation of part of the constituents of an ore?

A. I believe it was simply to give me all the information they had on oil processes.

Q. 31. And what information did they impart to you at that time?

A. As far as I remember, it was an alternative to the Cattermole second agitation, and consisted in the use of gas or air, introduced or generated in the pulp containing the agglomerations or imperfectly granulated mineral, for the purpose of bringing this up to the surface as a scum.

(Pages 1801-1802):

Q. 65. By which of these gentlemen were the instructions given to you?

A. By Mr. Sulman.

Q. 66. Can you state the nature of the instructions?

A. These instructions were to carry out a series of tests on the factors influencing granulation.

Q. 67. And while performing these tests did you observe part of the metalliferous mineral floating as a froth or scum?

A. As far as I remember, in the bulk of these experi-

ments there was a small quantity of floating mineral. This only reached appreciable proportions when the reduction of oil was carried down to very small proportions.

Q. 68. I presume the quantity of floating material increased gradually as the quantity of oil was reduced?

A. No, my impression is the quantity of floating material increased rapidly when the oil was reduced below a certain point.

Q. 69. And what was the certain point at which the rapid increase took place?

A. .62 per cent. of the oleic acid on the ore.

(Page 1803):

Q. 73. What did you do when you first tried your experiments with oil and reduced in quantity to .62 per cent. on the ore; I mean, did you immediately make your oral report that you had referred to to Messrs. Sulman, Picard and Ballot?

A. I called in Mr. Ballot to see one of these experiments performed, wherein froth was produced, but I cannot say which one it was. I may, therefore, have tried a further reduction of oil before making an oral report on it.

(Page 1817):

X-Q. 139. In Q. 66 you were asked as to the nature of instructions received by you, and in your answer to Q. 67 you speak of the reduction of oil being carried down to a very small proportion, and in Q. 137 this work, I take it, was referred to as experiments for ascertaining the effect of varying the quantity of oil upon granulation. Please state as accurately as you can what were

these instructions, so far as they related to the quantity of oil.

A. As far as I remember, the instructions were to start with large quantities of oil, say the upper limit of Cattermole's specified quantity, and reduce this as far as possible. In other words, to find the lowest limit at which any result could be obtained by the use of oil.

Froment Instructions.

(Vol. III, page 1000):

(*Remark*). If the ore contains more than five per cent. of metallic matter such as copper, lead, it will be necessary to add a little more oil. As a general rule, one may assume:

1	%	of	oil	for	ore	containing	up	to	5%	of	metals.
1½	%	"	"	"	"	"	"	"	10%	"	"
2	%	"	"	"	"	"	"	"	15%	"	"

It is very rare that one has to enrich ore containing more than 15% copper. In our countries, Italy, France, Spain, ore containing 15% of metallic copper, is considered very rich and is treated as such. In case of lead ore, concentration is continued until the ore contains 60% of lead, this later proportion is seldom exceeded.

Cattermole Oil Proportions Contained in Sulman & Picard Report of March 25, 1903, Addressed to John Ballot.

(Vol. III, pages 1021-1022):

Given these conditions the operation of the Cattermole process has become much simplified compared with the scheme originally put forward. It is sufficient to take the ore suspended in about three to four times its weight of water and to mix this to a uniform pulp in a suitable mixer, preferably of the Gabbett type; to this suspension, while still in a state of agitation, the oil emulsion is added. The proportions requisite may vary somewhat and are shown in the schedule. Roughly speaking, we have found that the oil addition equal to about 7 per cent. upon the mineral present in the ore is sufficient. A small amount of soap solution is also necessary to obtain good flocculation, and it appears to aid in the uniform dissemination of the added oil emulsion through the pulp in the mixer. A very short period of agitation is necessary to effect complete flocculation of the whole of the mineral, which readily subsides, leaving clear water above, opalescent with the soap added. The tendency of our work has been to show that a very small amount of soap is necessary, and we have continually cut this down, almost to the vanishing point; still a small amount of soap during flocculation appears to be advisable.

Sulman & Picard Report of March 25, 1903.

(Page 1025):

Firstly. Suitable crushing of the ore as specified.

Secondly. Flocculating the pulps with a small amount of soap and oil emulsion in the proportions given, using a fair proportion of thick oil to kerosene. (It is only necessary here to note that emulsions containing thick oil are rather more difficult to get completely "smooth," that is, free from unemulsified oil globules, than with kerosene alone; but with a little care and experience a perfect emulsion of thick oil is obtainable.)

Thirdly. Breaking down the flocculent precipitate by strong agitation with very dilute acid.

Fourthly. Gentle rolling to agglomerate the fine mineral particles into shot-like granules.

Fifthly. The separation of granules from gangue in a water up-current.

Sulman & Picard Report of May 5, 1903.

(Page 1027):

Cattermole Process.

We beg to report results of experiments on the above process.

Expt. No. 7. This test was made on Broken Hill ore ground to 60 mesh. 1000 grammes of ore was used in two lots of 500 grammes each, as the Gabbett mixer will not take more than 500 grammes, which portion was agitated with 600 cc of 0.2 per cent. sulphuric acid and 30 cc of soap emulsion. The emulsion was made up of 50 per cent. of oil and 2 per cent. soap; the oil being a mixture of two parts of residuum and one part of paraffine.

This charge was agitated about 10 minutes, half the time with the baffle, and half without. The two charges were then mixed and submitted to the rolling process in the Gabbett (without baffle) for a period of three minutes. This treatment yielded satisfactory granules.

The charge was then put through an up-cast separator to remove the light sands.

Sulman & Picard Report to John Ballot of September 24, 1903. (Re Cattermole Process.)

(Pages 1037-1038):

A certain amount of fine material as well as coarse is necessary to the building up of coherent granules, but the sieve analysis of the 60-mesh material just quoted shows that upon crushing to this maximum mesh quite a sufficient amount of material finer than even 120 is produced for all granulation requirements. The first granulations obtained from a trial on the new plant yielded concentrates containing 20.85 per cent. of insoluble matter, *i. e.*, gangue. Too much oil emulsion had been used in this case and by further reduction (to about 6 per cent.) granulation was found not to be interfered with, and the concentrates only retained 12.15 per cent. of insolubles. A still further reduction was made in the oil additions when it was endeavored to add oil emulsion in the proportion of about 5 per cent. of oil upon the actual mineral present in the ore.

Sulman & Picard Report to John Ballot of March 3, 1905.

(Pages 1099-1100):

We are in full agreement with the rest of Mr. Higgins' observations, and may summarize the work now being done at Aldermanbury Avenue as the determination of the following factors:

(1) Influence of acidity on granulation.
(2) Influence of temperature on granulation.
(3) Influence of speed of Gabbet agitation on granulation.
(4) Influence of ratio of ore to liquor on granulation.
(5) Influence of metallic salts on granulation.
(6) Influence of the size of particles and of the influence of slimes on granulation.
(7) Influence of the amount of oil on granulation.

The above factors are being determined on

(*a*) Oleic acid.
(*b*) Residuum oils.

Higgins Report of March 16, 1905, in which he gives the tabulations regarding the "birth" of the invention of patent 835,120—the Agitation Froth Invention.

(T. R., Vol. III, pages 1108-1109):

FURTHER REPORT ON THE CONDITIONS OF GRANULATION MARCH 16TH, '05. INFLUENCE OF THE PERCENTAGE OF OIL.

The effect of diminishing the percentage of oleic acid is to alter the type of oiling; the higher percentages producing granules, and the lower ones froth. 6 per cent. of oleic acid on the *mineral* is sufficient to form good granules without much froth. This froth consists of insufficiently oiled mineral mixed with large quantities of air. As this percentage of oleic acid is decreased, the time for clean-up of the sands is increased and more froth is formed. 0.62 per cent. oleic acid on the mineral is insufficient to form any granules, and nearly the whole of the mineral comes to the surface, on stopping the cone, as froth. 0.2 per cent. acts in the same manner, leaving the coarse sands with rather more mineral in them. (This is 0.1 per cent. on Broken Hill *Ore.*) In all cases the oil has been measured in cubic centimeters and the percentage calculated as though they weighed grams, but as the specific gravity of the oleic acid is less than unity this is not the case and all percentages will be lower than those actually given.

Details of Experiments.

Acid.	Oleic Acid.	% of Oleic.	Time.	Temp.	Remarks.
1.1%	15 cc.	3 % on ore	4 min.	30.5° C.	Very little float.
"	7½ cc.	1.5 % " "	4¼ "	31° "	Rather more float.
"	5.2 cc.	1.04 % " "	6 "	31° "	Still more float.
"	3.1 cc.	0.62 % " "	6 "	32° "	
"	1.6 cc.	0.32 % " "	7 "	31° "	Float vastly increased.
"	0.5 cc.	0.10 % " "	8 "	31° "	Float vastly increased.
"	0.5 cc.	0.1 % " "	4¾ "	29° "	Not finished.
"	0.4 cc.	0.8 % " "	6½ "	30.5° "	
"	0.5 cc.	0.1 % " "	8 "	31° "	
"	0.5 cc.	0.1 % " "	8 "	31° "	Weight of cones. 170 gms.
"	0.2 cc.	0.04 % " "	8 "	32° "	Apparently not much different.
"	0.1 cc.	0.002% " "	12 "	32° "	Little worse.
"	none	none	7 "	32° "	Very little float.
"	none	none	10 "	32° "	More froth.

Sulman & Picard Report to John Ballot of May 3, 1905.

(T. R., Vol. III, pages 1113-1114):

JOHN BALLOT, ESQ.,
Chairman,
MESSRS. THE MINERALS SEPARATION, LTD.,
62 London Wall, E. C.

Dear Sir:—

We beg to hand you herewith a statement of the new method of oil concentration which we have been engaged in investigating and working out in detail for the purpose of your forwarding to Mr. Courtney and his staff in Australia.

It will be best to start with a short statement on the principle on which the process depends.

In determining the lowest limit of oleic acid which could be employed in granulating, it was found that granulation practically stopped at a range of about 0.5 per cent. of oleic acid on the mineral (60-mesh Broken Hill), in an acid circuit somewhat below 1 per cent. in strength.

A certain amount of black mineral froth was, however, noticed as a result. On successively decreasing the amount of oleic acid *below* .5 per cent. it was found that whereas granulation ceased there was a growth in the amount of mineral float-froth under these conditions, and that the production of such float-froth appeared to reach a maximum when about .1 per cent. of oleic acid on mineral was used. This froth on collection was found to consist of oiled mineral slimes mechanically holding more or less coarse (oiled) mineral particles, the froth carrying between 70 to 80 per cent. of the total mineral present in the charge. The gangue slimes and the coarse sands are left quite white in the liquor below the froth, and the balance of the

coarse mineral not caught up in the black froth, but remaining mixed with the sands, is found to have been efficiently oiled and to be capable of complete recovery from the sands by table aeration.

This important discovery naturally suggested an economical method for the recovery of Broken Hill mineral quite different from any employed by you previously. The froth produced is not due to any action of the acid circuit upon traces of calcite present in the ore, *i. e.*, *not* to the liberation of any gas in the charge by means of the dilute acid employed in the circuit.

(Pages 1118-1119):

We may here conveniently note that other oils besides oleic acid may be employed in this modified recovery process, but so far as Broken Hill is concerned oleic acid gives by far the best results. Petroleum residuum added as emulsion, paraffine oil alone, R_3P_1 and R_1P_3 emulsions, have also been used, and all give small proportions of float, but do not act nearly so vigorously or efficiently on Broken Hill ores as plain oleic acid. Moreover .1 per cent. of oleic acid on the ore treated only amounts to some 6d. per ton, even assuming no recovery of the oleic acid, a question which we shall consider later.

APPENDIX.

Plaintiffs' Contentions Regarding the Invention of the Agitation Froth Patent 835,120, in Hyde Case.

Brief in District Court.

(Page 6):

The process of the patent in suit is an invention which has demonstrated itself, in the test of practical use, to be of world-wide importance to mankind.

(Pages 8, 9):

The process of the patent in suit is ideal, both in simplicity and economy. Taking as a basis the invention as pointed out in claim 1, we find it only necessary to mix or commingle powdered ore with water to form an ore pulp, to add a small proportion of an oily liquid having a preferential affinity for metalliferous matter, this proportion amounting to a fraction of one per-centum of the ore, to agitate the mixture until the oil-coated mineral matter forms a froth, and to separate the froth from the remainder by flotation. This involves the addition to the ore pulp of a small proportion of an oily liquid, such as the well known fatty oil, oleic acid, the proportion recommended in the patent being 0.1 per cent. of the ore (Spec., page 1, l. 99), subjecting the pulp to a brisk agitation which will beat into and out of it great quantities of air, and will effect the dissemination of this minute quantity of oil through the ore pulp so as to produce a coating on the metalliferous particles of infinitesimal thickness, and separating by flotation the mineral froth thus produced from the ore pulp thus robbed of its metalliferous material.

(Page 11):

Claims 9, 10 and 11 are the broadest claims. While clearly limited to the new agitation-froth phenomenon, they are not limited as to oil quantities except that the oil must be "a small quantity." These claims have a

broader scope than has as yet proved to be necessary for the protection of the agitation-froth invention, since no mine owner will use an ounce more of oil than is necessary, and the ores so far tested have not required more than the higher limit of the limited claims, but these claims would cover a wasteful use of oil such as defendant has suggested the possibility of, *and may in the future be necessary to cover an exceptional instance where the production of the agitation-froth phenomenon requires a quantity of oil more than any fraction of one per centum of ore, i. e., one per centum or more of the ore.* It is the duty of the patent attorney to draw broad claims including all possible future uses of the invention, as well as specific claims for what is believed to be the best procedure within the actual knowledge of the inventors at the time of the invention, and this duty has been well performed in this instance.

(Page 12):

The specification of the patent in suit is explained by Dr. Chandler, who considers only that part of the specification which is material to the issues, as above explained.

(Page 13):

Dr. Chandler's explanation is brief and clear, with quotations from the specification (C. R., pages 90-95, Q. 4). The important point as to the discovery is stated to be that the inventors have found that a considerable reduction of oil from that which produces the Cattermole granulation phenomenon, produces another and new phenomenon, the agitation-froth.

C. A. Brief, 0.

(Pages 16-17):

. . . In its first use at Broken Hill, Australia, oleic acid was used in the proportion of 2 lbs. to the long ton of ore (Chapman, C. R., page 176, Q. 25). Later re-

finements reduced this oil consumption to 1½ lbs. of oleic acid per long ton (Chapman, C. R., page 198, Q. 92), and it has been found that eucalyptus oil can be used on Broken Hill ore in the proportion of ½ lb. to the long ton (Higgins, D. R., page 394, Q. 117). In Finland the oil used was a mixture of oleic acid at from ½ lb. to 2 lb. per long ton, and eucalyptus oil at 2 lbs. per long ton (Chapman, C. R., page 200, Q. 102). In Sweden, wood tar oil is used in the proportion of 4 lbs. per long ton (Chapman, C. R., page 200, Q. 104), and in Chile a mixture is used of Texas fuel oil at 3 lbs. per long ton and American wood tar oil at 1 lb. per long ton. The variations in acid consumption are still greater. These are only examples, to which might be added defendant's use of the process, which at the time that he was detected was 3.2 lbs. of oleic acid per short ton of ore, or .16 per cent., as will appear from the testimony as to infringement to be hereinafter referred to.

(Pages 18-19):

A reference to the tests made at the time of the discovery of the invention, as brought out by the defendant, will show that in the careful investigations made at that time it was found that this proportion, 0.1 per cent., gave best results, although slight variations up and down from this proportion were not altogether useless. This report was made on March 16, 1905, a few days after the discovery, and was produced during the testimony of Mr. Sulman, one of the three joint inventors, as a witness for the defendant. All of the circumstances connected with the discovery of the invention will be referred to later in this brief under the heading, History of Agitation-Froth Invention, but a reference at this point to the report of A. Howard Hig-

gins, the metallurgist who performed the first experiments under the directions and instructions of the inventors, will be instructive (C. R., page 822). Here will be seen particulars of tests with oleic acid in the proportion of 0.32 per cent. of the ore, "float vastly increased"; 0.1 per cent., float again "vastly increased"; .04 per cent., "float apparently not much different"; and .02 per cent. (1 cc of oleic acid to 500 grams of ore), erroneously written as 0.002 per cent., "float little worse." Again (C. R., page 821), it is said that 0.62 per cent. of oleic acid on the mineral (0.31 per cent. on the ore) is insufficient to form any granules and gives a froth, and that 0.2 per cent. on the mineral (0.1 per cent. on the ore) gives more mineral in the froth. Again (C. R., page 823) an assay return is given of a test with 0.1 per cent. oleic acid, giving a concentration of lead 92 per cent. and zinc 94 per cent. With these results before them, the inventors suggested in their specification the limits of "0.02 per cent. to 0.5 per cent. on the weight of the ore" (Spec., page 1, lines 81, 82), and recommended 0.1 per cent. as "suitable and economical" (Spec., page 1, lines 99-101). Subsequent applications of the process to the treatment of millions of tons of ore has demonstrated that these careful tests, made at the time of the discovery, ascertained the characteristics of the agitation-froth phenomenon and determined the conditions of its economical production —the use of the process for the benefit and profit of mankind—and these characteristics and conditions have been true of every one of its numerous and extensive uses.

(Page 20):

This is the agitation-froth, the new phenomenon discovered by the inventors, a remarkable and wholly unexpected phenomenon. This phenomenon is described

by Dr. Adolf Liebmann, a chemist and physicist of international reputation, as follows:

> "It is a froth consisting of air bubbles, which in their covering film have the mineral embedded in such manner that they form a complete surface all over the air bubbles. The remarkable fact with regard to this froth is that, although the very light and easily destructible air bubbles are covered with a heavy mineral, yet the froth is stable and utterly different as far as this property is concerned from any froth known to me. It appears as if the minerals were protecting the tender air bubble like an armor, and, instead of destroying it, were actually guarding it. The froth has a long life. One feels tempted to say it is permanent, at least as far as metallurgical operations are concerned." (C. R., page 378, fol. 1133.)

(Page 21):

Dr. Charles F. Chandler, who has probably educated more mining engineers than any other man, and has been called upon to testify in the principal metallurgical controversies for the past forty years, thus describes this new phenomenon: 9th C. Appeal Page 3

> "The remarkable thing about the froth produced in this process is its permanency. The bubbles of air, with water films, are thickly coated with mineral particles and appear to be armored by these metallic particles. The froth piles up thickly and carries the great weight of the mineral particles, which are the heaviest particles of the ore. The oil has entirely disappeared from sight and sense. It cannot be seen and it cannot be felt, and the particles of mineral are just as bright as though there was no oil upon them at all." (C. R., page 666, fol. 1996.)

(Pages 24-25):

Next, commencing at page 2, line 13, is the statement of the possibility that the fatty acid which forms the microscopic coating on the "metalliferous matter which 9th C. Appeal Page 3

produces the froth'' may give rise to insoluble soaps, if soluble lime, iron or other salts are present in small quantity during the production of the froth or on the breaking down of the froth with alkali, and that if this happens it will not be of disadvantage to flotation. This relates to oil recovery by alkali, which changes the oil or fatty acid to a soap, and to possible results of such procedure when the liquor is used again in closed circuit, and is, as above stated, the subject of claims 8 and 13, which are not in issue.

(Pages 32-33):

C. A. Brief, 6.

. . . The second of these patents, No. 793,808, is known as the bubbles patent, and represents the first and unsuccessful efforts of Sulman and Picard to utilize flotation in oil concentration with a smaller quantity of oil than was required in the Elmore bulk oil buoyancy flotation process. The application for this patent was filed October 5, 1903, during the early struggles of Messrs. Sulman, Picard and Ballot to discover or devise a satisfactory process of ore concentration by oil. The quantity of oil to be used is stated to be

> ''insufficient to raise the oiled mineral by virtue of the flotation power of the oil alone.'' (Spec. 793,808, page 1, lines 26, 27.)

that is to say, it is something less than 6,000 pounds to the ton of ore; and it is also stated to be such that the solid particles are

> ''moistened by oil.'' (Spec., 793,808, page 1, line 19.)

To moisten the particles requires at least the Cattermole quantities, which were the smallest quantities known to be usable in 1903. It is a characteristic of the agitation-froth process that the minute quantity of oil used disappears from sight and sense.

(Page 61):

Thus it will be seen that the Cattermole granulation plant installed at Broken Hill, Australia, was a reproduction on a large scale of the experimental plant shown in the "Photograph of Australian Model Plant," . . . Mr. Chapman testifies:

> "We started the plant on dump tailings and treatment proceeded on Cattermole lines for but a few days. The oil consumption alarmed our clients and I was instructed to use every endeavor to bring this down." (C. R., page 174, Q. 22.)

9th C. C. Appeal Page 87

This oil consumption, with dump tailings, which run about 30 per centum mineral (Chandler, C. R., page 644, fol. 1932) with the standard determined for this plant,

> "five per cent. on the sulphide mineral constituents or mineral content of the ore" (Chapman, C. R., page 171, Q. 9)

would amount to about 1½ per cent. on the ore, or 33.6 pounds per long ton and 30 pounds per short ton of ore. This was the oil consumption which alarmed the mine owners, the Sulphide Corporation, and which Mr. Chapman then used every effort to reduce.

(Page 62):

. . . The best that he could do was to place all his reliance on the table flotation annex to the Cattermole apparatus and to reduce the oil consumption to .8 per cent. of the ore, 17.92 pounds per long ton and 16 pounds per short ton of ore. Under these conditions good granulation was impossible, mineral flocks were formed and these were floated by air exposure on the table and surface tension flotation. Mr. Chapman says:

9th C. C. Appeal Page 88

> "The formation of good shotty granules was impossible under these conditions, mineral flocks

> being formed, and these readily separated on the skin flotation table on the lines in which I had been instructed by Messrs. Sulman, Picard and Ballot previous to my departure for Australia. These trials took considerable time, and it was a few weeks before this best condition was reached. The plant proceeded to run on these lines." (C. R., page 174, fol. 522.)

Here we have the closest approach in oil consumption which was ever made to that of the agitation-froth process, actually made, in fact, after the discovery of that process, since that invention was made in early March, 1905, in England while this determined effort to reduce the oil consumption to a minimum by a metallurgist skilled in the whole prior art, was made in Australia in April or May, 1905.

(Pages 63-64):

. . . Further, when the agitation-froth discovery was communicated to him through the course of the mails, fully four weeks from London to Broken Hill, Australia, he welcomed it as a discovery of great value (C. R., page 175, fol. 523) and immediately changed over his plant, the plant which represented so much care and thought and effort, so as to carry out in it the agitation-froth process (C. R., page 175, Q. 24), and produced thereby the agitation-froth, which he says

> "was entirely different to any float that I had seen in the other processes in which flotation had been attempted" (C. R., page 175, fol. 525),

and reduced the oil consumption to two pounds of oleic acid per long ton of ore (Chapman, C. R., page 176, Q. 25), 0.089 per cent. on the ore, 1¾ pounds per short ton of ore. Thus, under Cattermole, he started with an oil consumption, per long ton of ore, of 33.6 pounds; by spoiling Cattermole, and recovering by table flotation, he reduced this to 17.92 pounds, and by in-

troducing the agitation-froth process in accordance with the directions of Messrs. Sulman, Picard and Ballot, he brought this down to 2 pounds. The work then started still continues and millions of tons of ore have been treated. The oil consumption was soon reduced to 1½ pounds per long ton (Chapman, C. R., pages 197, 198, Q. 92).

(Pages 65-66):

HISTORY OF THE AGITATION-FROTH INVENTION.—DISCOVERY.

In the next Sulman and Picard report, of March 3, 1905, we find a summary of the work then being done at the Aldermanbury avenue laboratory as the determination of the influence of seven factors on granulation, with the employment, first, of oleic acid, and, second, of residuum oils. The seventh of these factors is:

> "Influence of the amount of oil on granulation" (C. R., page 815).

It was the investigation of this particular factor as a part of the scheme of investigation, which brought about the discovery of the agitation-froth process.

(Page 66):

. . . Defendant therefore probed deeply into the facts as to this investigation and has proved that these seven instructions were arrived at in a conference of the three inventors, Messrs. Sulman, Picard and Ballot; that they were written out by Mr. Sulman and handed by him to Mr. Higgins in the presence of Mr. Ballot; that they were supplemented, as to the seventh factor, by oral instructions to reduce the quantity of oil step by step so as to find, as Mr. Higgins says, "the lowest limit at which any result could be obtained by the use

of oil" (D. R., page 399, X-Q. 139), and that the work of Mr. Higgins, under the supervision and direction of the inventors, in thus reducing the oil step by step, resulted in the discovery of the agitation-froth process.

(Pages 68-69):

th C. C. A. ppeal Brief, 'age 90.

And, finally, Mr. Higgins, the metallurgist who carried out these instructions, fully corroborates this testimony, testifying as follows:

> "X-Q. 139. In Q. 66 you were asked as to the nature of instructions received by you, and in your answer to Q. 67 you speak of the reduction of oil being carried down to a very small proportion, and in Q. 137 this work, I take it, was referred to as experiments for ascertaining the effect of varying the quantity of oil upon granulation. Please state as accurately as you can what were these instructions, so far as they related to the quantity of oil.
>
> "A. As far as I remember, the instructions were to start with large quantities of oil, say the upper limit of Cattermole's specified quantity, and reduce this as far as possible. In other words, to find the lowest limit at which any result could be obtained by the use of oil." (D. R., pages 398, 399.)

(Pages 85-86):

th C. C. A. ppeal Brief, age 110.

There is one almost unbelievable characteristic of the concentrate produced that was not appreciated when this report was written. It was believed necessary to clean off the "infinitesimal amount of oil" to render "the concentrates fit for vanning separation into blende and galena" (C. R., page 833, fol. 2498). This had always been necessary in prior work. The oiling of the mineral moistened it and made it sticky. This cleaning has, however, never been necessary in the working of the agitation-froth process. The infinitesimal oil coating has here no adhesive effect whatsoever, and the concentrates may be freely tabled or vanned.

(Page 86):

The installation of the agitation-froth process at Australia was quickly effected. Six large scale Gabbetts, in series, were already installed (Chapman, C. R., p. 173, Q. 19), and at work in a hybrid process of oiling by agitation in less than Cattermole proportions, .8 per cent. on the ore, separation from fine sands or gangue by sinking the mineral in an upcast, which carried upward and to waste the fine sands, gentle agitation in a second series of Gabbetts, without baffles, then separation of the mineral from the coarse gangue by skin flotation on tables in accordance with the table flotation patent No. 879,985 (C. R., page 174, Qs. 20-22).

9th C. Appeal Page 1

(Page 132):

As to the fact that the production of the agitation-froth is in itself an indication of the use of the agitation-froth process, Mr. Sulman, testifying as a witness for defendant, says:

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> "The phenomenon of the agitation-froth production is in itself an indication of the right amount of oil to employ" (D. R., page 264, Q. 119),

and he further states that an operator may be entirely governed by the result to be obtained, to-wit, the production of the agitation-froth (D. R., page 266, Q. 123).

(Pages 133-134):

As to the effect of slightly increasing the oil supply above the proper amount for the production of the agitation-froth and of slightly diminishing the oil supply below such proper amount, we have the testimony of Mr. Chapman, who installed the agitation-froth process in Australia, Finland, Sweden and South Wales, as follows:

9th C. Appeal Page 1

"110 Q. What has been your experience when

in using the agitation-froth process on a commercial scale, with a normal and proper consumption of one and a half pounds of oil per ton of ore, this procedure has been varied by increasing the oil feed to two and a half pounds per tone of ore?

"A. The mineral froth being produced on the spitz boxes loses at once some of its natural color and lustre and becomes dull in appearance. The quantity of froth being recovered on No. 1 box is considerably lessened. The froth on No. 2 spitz is slightly increased and the same with No. 3 box. The tailings on examination immediately show increased losses of sulphide mineral. These losses take the form of well oiled agglomerations.

"111 Q. And what has been your experience when the normal and proper feed of one and a half pounds of oil per ton of ore has been diminished to half a pound of oil per ton of ore?

"A. The froth being recovered immediately diminishes in quantity and the color shows the presence of slime gangue. The supporting liquor of the spitz box immediately changes in appearance and shows the natural color of the ore slimes. The tailings become very dirty and show no sign of what we know as a good 'clean-up.' In fact the whole treatment suffers and unless the oil feed is restored to its normal condition a serious drop in recovery takes place with the production of a lower grade concentrate." (C. R., page 201.)

(Page 135):

9th C. C. A. Appeal Brief, Page 163.

And this testimony is absolutely unaffected by the fact, apparently discovered by defendant's expert, that if enormously extravagant and wasteful quantities of certain oils are used with defendant's ore, sixty-six times so much as is necessary, it is possible to so manage tests in a slide machine as to obtain a fair recovery of floating concentrate. These tests are described by Dr. Byrnes (D. R., pages 165, 166). He first used .3 cc. of cotton-seed oil and produces an agitation froth with good recovery. Then under the same conditions he uses 20 cc., or "66 times as much," of the same oil,

and, starting with 99.9 grams of zinc in his ore, obtained 101.9 grams of zinc in his concentrate and 2.9 grams zinc in his tailings, a total of 104.8 grams of zinc (Liebmann, C. R., page 478, fol. 1434), a truly remarkable result, since these tests always show a slight loss of zinc in the apparatus. He then used the same wasteful quantity of olive oil, and obtained a reasonable and very good recovery. He then used the same wasteful amount of oleic acid and failed. He then used half the amount of a modified oleic acid, still thirty-three times the amount which had given a good result in cotton seed oil, and obtained a good recovery. These tests prove nothing of any value. Mining companies are not inclined to unnecessarily mulitply the cost of an important item of expense by thirty-three or sixty-six.

(Pages 135-136):

It may be noted that these tests of Dr. Byrnes were untruthfully alleged by him to be tests of the Froment process of the prior art, but that will be considered under the heading, "Froment."

To further probe into this remarkable result of wasting oil, Mr. Higgins made a test at Butte (C. R., page 680, Q. 31) in a very small continuous testing plant, of Elm Orlu ore, from a mine adjacent the Black Rock mine, producing defendant's ore. He used the same proportion of cotton seed oil as Dr. Byrnes had used, sixty-six times as much as was necessary, 3.6 per cent., and obtained a copious oily float, which at a distance looked like the agitation-froth. This float was dense and occasionally fell down in masses. The tailings contained granules. The recovery was only 50 per cent. of the zinc. Thus the recovery obtainable by careful management of a slide machine was not duplicatable nor was any practical recovery obtainable in a continuous apparatus.

9th C. C. A. Appeal Brief, Page 164.

(Page 137):

9th C. C. A. Appeal Brief, Page 164.

These tests make it quite clear that when Dr. Byrnes' oil-wasting tests are repeated in continuous plants such as defendant is operating, the results are out of all reason, and that the larger the plant, the worse the result.

IN THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT.

James M. Hyde,
Appellant,
vs.
Minerals Separation, Limited, and Minerals Separation, American Syndicate, Limited,
Appellees.
No. 2346.

Brief for Appellees.

(Pages 9-10):

ORE CONCENTRATION BY OIL.

The patent in suit is for a new process of ore concentration wherein the preference of oil for metallic particles is utilized. The invention is the culmination of efforts to solve the problem of the economical concentration of those ores in which the valuable metals are present in a metallic condition, as in the abundant sulphide ores of zinc, copper and lead, by utilization of the old and well known preference of oil for metallic substances.

(Pages 11-12):

The Cattermole process was a remarkable step forward in diminution of the amount of oil required, reducing this amount to from 4 to 6 per centum of the weight of metalliferous mineral in the ore. The Cattermole process was adapted only for comparatively rich ores. The ore used was Broken Hill ore, of say 50 per cent. mineral or sulphide content. For this ore Cattermole required from 40 to 60 lbs. of oil to the ton of ore. For the same ore, the Elmore process required, roughly, 6,000 lbs. of oil to the ton of ore. The process of the patent in suit, which for the first time

brought this oil consumption to practical proportions, requires 0.1 per cent. of the ore, regardless of the mineral content, the oil being only one one-thousandth part of the ore (2 lbs. of oil to the ton of ore). This minute quantity of oil produces the remarkable new phenomenon known as the agitation-froth. This phenomenon and the economical and practical method of its production were discovered by Messrs. Sulman, Picard and Ballot in March, 1905, after long and arduous efforts to develop the Cattermole process into an economical and workable process of ore concentration.

(Pages 14-15):

The process of the patent in suit is ideal, both in simplicity and economy. Taking as a basis the invention as pointed out in claim 1, we find it only necessary to mix or commingle powdered ore with water to form an ore pulp, to add a small proportion of an oily liquid having a preferential affinity for metalliferous matter, this proportion amounting to a fraction of one per centum of the ore, to agitate the mixture until the oil-coated mineral matter forms a froth, and to separate the froth from the remainder by flotation. This involves the addition to the ore pulp of a small proportion of an oily liquid, such as the well known fatty oil, oleic acid, the fraction of one per cent. recommended in the patent being 0.1 per cent., one-tenth of 1 per cent., of the ore.

(Page 24):

. . . It is a characteristic of all processes dealing with ores that each ore presents a slightly different problem, and as the process of the patent in suit has been put at work in different parts of the world, the conditions of its use have slightly varied. In its first use at Broken Hill, Australia, oleic acid was used in

the proportion of 2 lbs. to the long ton of ore (Chapman, R., p. 376). Later refinements reduced this oil consumption to 1½ lbs. of oleic acid per long ton (Chapman, R., p. 391), and it has been found that eucalyptus oil can be used on Broken Hill ore in the proportion of ½ lb. to the long ton (Higgins, D. R., p. 361, Q. 117).

(Pages 126-127):

The next mine installation was at the Braden Mines, in Chile. Here a copper ore containing 3 per cent. of copper is treated by the agitation-froth process. A plant with a capacity of 250 tons per day has been installed, and a plant of 1200 tons per day is in course of erection. With acid at 5 to 6 pounds per ton of ore, Texas fuel oil at 3 pounds per ton of ore, and American wood tar oil at one pound per ton, and no heating, recoveries are at eighty-five to ninety per centum (R., pp. 394, 395).

Argument by John H. Miller on Behalf of Appellees.

(Page 4):

The invention in suit is a radical departure from any of the above suggested methods and from any known method in the art. It is exceedingly simple. Indeed, its simplicity is its dominant feature. It may accordingly be described in a few words.

The ore is finely pulverized and mixed with water to form a freely flowing pulp. To this is added a minute quantity of oil varying from two one-hundredths of one per cent. (.02%) to one-half of one per cent. (.5%) on the weight of the ore according to the character of the oil used. The preferable percentage is one-tenth of one per cent., *i. e.*, two pounds per ton of ore. This mixture, consisting of a large quantity of

freely flowing pulp and an infinitesimal quantity of oil, *is then violently agitated in a mixing vessel,* from two and a half to ten minutes. *When the agitation is stopped,* the gangue matter sinks to the bottom of the vessel and the metalliferous matter rises to and floats on the surface of the water in the form of a thick coherent permanent froth or scum.

(Page 11):

. . . According to the patent a minute quantity of oil, preferably one-tenth of one per cent. in amount on the ore (*i. e.,* two pounds to the ton) is mixed with a very large quantity of water and powdered sulphide ore and the mass is then violently agitated. The result of this violent agitation is to break up the oil into minute and almost infinitesimal particles and to whip into the liquid mass large quantities of air whereby myriads of air bubbles are generated while the sulphide particles and gangue particles are held in suspension.

(Pages 26-27):

In the process of the patent in suit the specific gravity of the oil cuts no figure whatever. The quantity of oil used in covering the metallic particles is so infinitesimal that it becomes a negligible quantity as affecting the specific gravity of the particles. In other words, the oil-coated particles are practically and for all intents and purposes of substantially the same specific gravity as the particles themselves. The basis of the process is the utilization of the doctrine of surface tension and the carrying power of air bubbles.

(Pages 54-55-56):

It is also argued by the learned counsel for appellant that the patent is void because it fails to specify the exact amount of oil necessary and merely gives a

range, leaving to the user the task of ascertaining the exact amount within the range by experiment. . . .

But the case of *U. S. Mitis Co.* v. *Midvale Steel Co.*, 135 Fed., 105, seems to be *conclusive.* The invention there involved was a process for making steel castings homogeneous so as to prevent blow-holes, and it consisted simply in adding to the molten steel when it is about to be poured into the mold a minute quantity of metallic aluminum. In that behalf the specification said:

> "I have found that the use of a minute quantity, never exceeding one per cent. by weight—preferably from one-fifth to one-tenth of one per cent. by weight—of metallic aluminum added to the molten iron has the desired influence, and even a very much smaller percentage has an appreciable influence."

Here, then, we have a strictly analogous case. The directions were to use not over one per cent. and preferably from one-fifth to one-tenth of one per cent. of aluminum. The directions of the patent in suit are to use less than one per cent. of oil, from two-hundredths to five-tenths of one per cent., and preferably one-tenth of one per cent.

(Page 69):

. . . We have already pointed out the fact, and sustained it by citation of authorities, that in the case of patents relating to chemical and physical forces but little reliance can be placed on analogies drawn from mechanical patents. The reason for this is that a very small change in detail or proportions may produce a radically new result in the case of chemical and physical patents, whereas in the case of mechanical patents a change in degree and proportion will not often produce a result different in kind.

(Pages 74-75):

The invention in suit fulfills the above requirements. These patentees have certainly added something of value to the sum of human knowledge, they have made the world's work easier, cheaper and safer, and most assuredly a return to the prior art would be retrogression. Millions of dollars' worth of tailings have been successfully worked by this process, which prior thereto were unworkable by any known process. Millions of dollars of profit have accrued to the owners of the patent. The process has been put into use in many places throughout the world, and always with success. It has displaced other processes. Indeed, the only other processes ever used in practice were Elmore and Cattermole. They are now discontinued, and the process of the patent in suit has been substituted therefor. The result produced by this process is radically new. The agitation-froth is a new phenomenon in the metallurgy of ores. The eminent chemists produced by us have so testified. The cost of practicing the process is inconceivably small; ten cents' worth of oil to the ton is all that is necessary in the shape of chemicals. The other substance used is the natural atmosphere of the world itself, an inexhaustible store-house upon which we can call at will and without cost. Mix a ton of ore pulp with ten cents' worth of oil and vigorously agitate the mixture. That is the process, so far as claim 1 is concerned. Nothing can be simpler, nothing can be cheaper, and the result thus produced is so wonderful and marvelous that it may be denominated as spectacular.

Printed Oral Arguments on Appeal, Ninth Circuit Court of Appeals.

MR. WILLIAMS (page 52):

Now, this Cattermole process was a beautiful process, a reliable process, the first process which utilized slimes. Elmore had to reject them, all the valuable slimes, as much mineral as gangue. You could not grind ore without getting slimes, and with a brittle ore, such as blende, you get a large quantity of them. Cattermole was the first man who could treat slimes. It was a very important point. This Cattermole process we worked on for two years and three months. We exhaustively investigated it and improved it. We erected a plant. The plant was not finished until after the present invention was made. The oil consumption, even by Cattermole, proved to be too large. But it is a very interesting process, a very practical process, subject only to the objection that it uses too much oil. I am going to show to the court the Cattermole process as it was carried on in our laboratory and as it was installed in Australia in a plant of large dimensions.

(Pages 55-56):

The patent recognized as a suitable and economical fraction of 1 per cent., one-tenth of 1 per cent., one one-thousandth of the ore, two pounds of oil to the ton of ore; and the practical application of the process in the treatment of millions of tons of ore has mainly been at that recommended proportion. The greatest amount of oil that has ever been necessary has been four pounds of oil to the long ton of ore; the smallest amount that has ever been used has been a trifle under one pound; the smallest amount that is usable is with an oil which is rather an expensive oil—eucalyptus oil—one-half a pound of oil to the ton of ore.

Now, what happens to this trace of oil which coats the mineral? It disappears from sight and sense. You take your concentrates and you cannot see any oil on them with a microscope of ordinary character; you cannot see any oil on them, you cannot feel that they are oily; you can take them and subject them to gravity treatment, shake them on tables, and you will find that the oil has absolutely disappeared. It is sensible only to chemical treatment. The metalliferous mineral is so thinly coated, the coating is so microscopic, it is not a molecule thick, yet you have all the affinities in the operation of the metal with the co-operation of the oil, and you produce a froth, which is composed of water films, no oil in the water at all, water films with these oily coated particles all about the bubble, making a complete armor for the bubble, and produces that permanency which characterizes the agitation froth.

(Pages 59-60):

Now we come to another group of claims, 9, 10 and 11. These are the claims that were referred to by appellant's counsel as being very broad.

The defendant has infringed these broad claims, and he has also infringed the specific claims. The defendant has used 3.2 pounds of oil to the ton of ore, 0.16 per cent. That is decimal 16 per cent. The specification here of the quantity of oil is a small quantity of oil. It may be possible that in the future somebody will use more than a fraction of 1 per cent. of oil and get the new result which was never obtained before we got it.

(Page 65):

All those things were valuable when we were dealing with appreciable quantities of oil; but in the process in the patent in suit the amount is so slight that it does

not pay to use any other material to get it back, 2 pounds to the ton of ore, 10 cents to the ton at the greatest, and lost to the sight and the senses. Only will it be necessary to remove that in the future if we put the concentrate through a chemical process. If we did that the trace of oil in the mineral would manifest itself. If we had a cyanide it might be necessary to clean off that little microscopic film of oil.

> "We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent. on the ore—granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum. This tendency is dependent on a number of factors."

(Page 68):

That is undoubtedly true. The remarkable fact is, it does not vary in proportion to the richness of the ore. Down in the Braden mine, in Chile, we used 4 pounds of oil to the ton of ore, and the ore contains 3 per cent. of copper. Out in Australia, in the Broken Hill area, 50 per cent. of ore in mineral content, we used there slightly less than a pound. Our phenomenon is distinguished, differentiated, from everything else by the fact that it does not make any difference how rich the mineral is; in practice, in the treatment of thousands of tons daily, we use 4 pounds for a 3 per cent., or maybe a 6 per cent., mineral content, and we use less than a pound for an ore containing from 50 to 55 per cent. mineral content. But these variations are not very great, and they are all within the specific limitations of the patent in suit.

(Pages 80-81):

. . . The Cattermole patent does not mention heat. But it was discovered in the laboratory work that heat helped along the Cattermole process; it diminished the period of oiling. Then it was discovered, it was slowly worked out, it had been worked out in the Cattermole, that sliming was an advantage. The elements which were assembled together by this long period of research were a violent agitation, such as was obtainable in the Gabbett or cone-mixer, oleic acid, heat, fine crushing without de-sliming, and then one other factor, the reduction of oil.

(Page 82):

There was then asked specifically what the instructions were as to the reduction of oil. It may be remarked here that the instructions on the line of those that I read, the seven factors, were made out in writing. The three inventors got together and they made out a list of the topics and this was handed to Mr. Higgins by Mr. Sulman in the presence of Mr. Ballot.

> "The instructions which I received from Messrs. Sulman, Picard and Ballot, pursuant to which I carried out the experiments described in my report of March 16, 1905, were, so far as they related to the quantity of oil, to start with large quantities of oil, say the upper limit of Cattermole's specified quantity, and reduce this as far as possible. In other words, to find the lowest limit at which results could be obtained by the use of oil."

Mr. Miller (page 98):

The agitation froth, which is produced by this patent, and an example of which is found in that jar over in the window, there, is a froth of pure sulphide metals, uncontaminated with oil or anything else. All you have to do is to gather that froth from these vessels, dry it

out, and take it to the smelter, and when it is taken to the smelter, then the operation of separating the pure metal from the sulphur is carried on in the smelter furnaces. That is all that has to be done.

Now, it is a known fact that no smelting furnace will receive for treatment an ore of any kind that has any oil in it, because oil is detrimental to the furnace treatment, and they will require you to separate the oil from it before they will treat it, and in order to find that out, they test every ore that is brought there.

(Pages 98-99):

. . . Now, the secret of that, if your Honors please, is simply this, that so small a quantity of oil has been used that when it comes up into the fermented froth, it is lost to sense and to sight; you cannot detect any oil in that froth, except by a minute chemical analysis, and then you find only a trace of oil; what the chemists say a trace; it is a negligible quantity. That is what all the witnesses have testified to on our side of the case, that the peculiarity about this froth is that it is a pure metallic froth, uncontaminated by oil or anything else, and requiring only to be dumped into a furnace in order to be recovered. Nothing of that kind has ever been done before.

(Page 99):

By some chemical laboratory manipulation, the learned counsel have produced in these four jars over here a froth. It is not the froth of the patent, because the froths which they have produced over there are froths that are contaminated by oil, and froth which would have to be separated before they could be operated upon by a smelter. It is not the froth of the patent that we have in those jars over there. There is a general outward appearance of similitude when

first produced between these froths and the froths produced by us, but is only the similitude of a corpse to a living being; the outward delineation or form is there, but the life is gone and is not there. The two things are not the same, although they have some outward resemblance. These things that they produce there were never produced in practice, but are merely laboratory experiments, which they have produced for the purpose of their argument. They do not pretend or claim that they were ever used or that they had any useful purpose whatever; but they only claim that they can produce our froth by using excessive quantities of oil. We say in answer to that, you do not produce our froth by the excessive quantities of oil. You produce a froth which is not our froth, in that it is a froth, and that is admitted, made with large quantities of oil, and, therefore, is useful for the purpose for which our froth is used.

(Page 100):

. . . The one point I make is that the product, the result produced by our process, is absolutely novel in the art. I say that is proved by the testimony of witnesses, and is proved by an examination and test of these various froths themselves, ours being *a pure metal froth, and theirs being an oil froth,* one, ours, being of great utility, as evidenced by a substantial use, theirs being absolutely of no utility whatever, as evidenced by the fact that it has never been used, and never will be used, as long as ours is used.

Brief of Petitioners-Complainants in Supreme Court—Hyde Case, Re Petition for Writ of Certiorari.

(Page 2):

The process of the patent in suit is known as the agitation-froth process. Essentially it consists in the violent agitation of a pulp of finely ground ore and water with a minute quantity of oil, resulting in the production of a mineral froth which floats upon the surface of the liquid, carrying with it the valuable metal contained in the ore, while the gangue or rock particles remain in the liquid. A small quantity of acid or moderate heat or both are sometimes additionally employed.

(Pages 7-8):

In contrast in the Privy Council judgment it is said of the respondents' process there (the process of the patent in suit here):

> "The real difficulty which their Lordships have to determine is whether the Respondents in the process of separation which they employ, entrap or coat and hold or carry the metallic particles in oil, using oil as the selective agent. The Respondents deny that they in any way use the Appellants' invention, and say that their process is essentially distinct, and that its successful operation depends on the law of surface tension. It is not incumbent on the Respondents to explain the law on which the success of their process depends." (Rec., p. 1358.)
>
> . . . . . .
>
> "Apart from any question of theory, the Respondents use oil in their process under conditions which make it almost impossible to entrap or coat and hold the metallic particles by the selective agency of oil. The respondents use a thin oil at a temperature of 120° Fahr., the quantity is minute, not more than 2 or 3 pounds to a ton of ore, or

> about 2 or 3 pints of oil to 10,000 pints of water; the resulting concentrate is practically free from oil and no mechanical contrivance to separate the oil from the metallic particles is required or used; the residue of the first concentration is further treated without any further addition of oil . . . their Lordships accept the evidence of Professor Pollock (defendant's expert) . . . summarized as follows: Professor Pollock is referred to his earlier evidence, and states that he does not think that the small quantity of oil introduced in the defendants' process necessarily performs any other function than permanency in the froth and extremely minute emulsion. He allows that there may be oil in excess, and that some of the particles may get oiled, but states that this is entirely and absolutely unessential. He does not however think that more than the necessary quantity of oil is introduced to effect concentration, but that having regard to the nature of the problem it is a matter of conjecture and exact calculation is not possible. Finally he reiterates his opinion that the defendants' process can be accounted for without assuming selection of the metallic particles by oil." (Rec., pp. 1359, 1360.)

In the House of Lords' judgment, the Earl of Halsbury, considering the Elmore patent there in suit and the prior Everson patent, hereinafter referred to, and contrasting them with the defendant's process (the process of the patent in suit here) said:

> "My Lords, I am of opinion that the two inventions are essentially different. I mean by the two inventions those which might be technically described, the one upon the selective action of oil, the other upon surface tension. That the two processes are in these respects totally different cannot be denied, and the acidulation which is supposed to incriminate the latter process with infringement is common to the first process and to another (Everson) which was invented and patented before it" (*infra*, p. 46).

In other words, the agitation froth process depends

upon the surface tension, the physical law controlling the production of the agitation froth, and the Everson and Elmore patents depend upon the selective action of oil.

(Pages 9-11):

Lord Shaw then gives consideration to the defendants' process as described in the British patent corresponding to the patent in suit here, and then as to the question of infringement by that process of the Elmore patent, says:

> "nor do I see my way to hold that there has been any contravention of the 1901 (Elmore) patent by the application of the acid to a mixture in which the oil has been reduced from bulk to the merest fraction, and especially when froth instead of oil has been secured, along with the law of capillarity or surface tension, as the main floating and separating agent" (*infra,* p. 60).

Again, in the House of Lords decision, Lord Atkinson says of the process of the defendant there (the process of the patent in suit here):

> "in their process this mysterious affinity of oil for the metallic particles of the ore is availed of, yet the oil is used in such relatively infinitesimal quantities, that the metallic particles are only coated with a thin film of it, and the lifting force is found, not in the natural buoyancy of the mass of added oil, but in the buoyancy of air bubbles which, introduced into the mixture by the more or less violent agitation of it, envelope or become attached to the thinly oiled metallic particles, and raise them to the surface, where they are maintained by what is styled the surface tension of the water" (*infra,* p. 51).

The House of Lords had before it the British patent corresponding to the patent in suit and evidence of the use of the process described therein. The Privy Council had before it evidence of the very extensive use of

that process in Australia. Their views as to the essential characteristics of that process were reached after the most careful and exhaustive consideration, and, as will be seen, their conclusions are irreconcilable with the opinion of the Circuit Court of Appeals of the Ninth Circuit as to the same process.

As to the prior art, there is a marked divergence of opinion between the three judges of the Circuit Court of Appeals of the Ninth Circuit on the one hand, and the ten Law Lords of England who participated in the two judgments above referred to, on the other hand. The Circuit Court of Appeals, after reviewing the patents of the prior art, including the Haynes British patent No. 488 of 1860, and the Everson United States patent No. 348,157, of 1886 (Rec., p. 1277), held:

> "The froths are all similar in appearance, they all rise to the surface after the same amount of agitation, they all gather with equal efficiency the same quantity of metal, and all may be removed from the surface in the same way" (Rec., p. 1285).

In the House of Lords judgment this Everson patent is repeatedly referred to (the Lord Chancellor, Lord Loreburn, *infra,* p. 45; Lord Atkinson, *infra,* p. 51; Lord Shaw, *infra,* p. 61; and by the Earl of Halsbury, in the quotation above given and the reference to the dilemma put by Mr. Justice Neville, *infra,* p. 48, see Justice Neville's judgment, High Court of Justice, 25 R. P. C., 741, 756), yet Lord Shaw says that the process of the defendant there (of the patent in suit here) is "a new method of separation" (*infra,* p. 59), and then repeatedly quotes, from the Sulman, Picard and Ballot British patent corresponding to the patent in suit here, language exactly repeated in the patent in suit here, evidencing the fact that the production of a mineral froth by agitation is the dominant characteristic of this process and was new.

(Pages 15-16):

We have above set forth particulars wherein the decision of the Circuit Court of Appeals of the Ninth Circuit and the judgments of the British courts are in conflict. In the evidence in the present suit and in the decision of Judge Bourquin, appealed from, it very fully appears that the novelty of the agitation froth process is *novelty* in *kind* and *not* in *degree*. Judge Bourquin says:

> "The process in suit is so clearly new that no exhaustive discussion of facts, cases or law is necessary to distinguish it from other processes or to demonstrate its novelty. The patentees herein discovered a new, cheap, simple, practical, and useful way or process to combine oil and air, and, by agitation, to float and secure the metallic contents in ore concentration" (Rec., p. 42).

It appears in the evidence and is in fact stated in the opinion of the Circuit Ciurt of Appeals that petitioners' inventors were the first to employ oil in the minute quantity specified in conjunction with vigorous agitation of the pulp, and the first to discover the remarkable result that followed.

It appears also in the evidence that this discovery was made in the course of a series of experiments in which the conditions, including the quantity of oil employed, were progressively varied.

The Circuit Court of Appeals held that while this discovery was a valuable contribution to the art, it was merely a discovery of the smallest quantity of oil which would produce an old result and that the patent was merely an attempted monopoly of the right to use oil economically in an old process.

It is, however, mathematically demonstrated in the evidence (and is not contradicted) that the separation and flotation of the valuable metal could not be ac-

counted for on the *theory* or by the *mode of operation* of the prior oil flotation processes. The quantity of oil present was far below the quantity necessary for that sort of operation.

It appears, too, in the evidence (and is not contradicted) that when in the series of experiments referred to a certain point was reached in reduction of the quantity of oil—a point where the quantity of oil was already minute—the nature of the result began suddenly and quickly to change, and whereas reductions of the quantity of oil above that point produced progressively poorer results, continued reduction of the now minute quantity of oil below that point, produced a rapidly improving result, both unexpected and startling, accompanied by a wholly *novel* froth phenomenon, until the point specified in the patent was reached, when a maximum effect was produced (Rec., pp. 895-898; p. 356).

(Page 17):

It appears in the evidence, just as it appears in the judgments of the British courts, that the reduction of the quantity of oil to the minuteness specified in the patent, in conjunction with the vigorous action specified, induced a new and different principle and mode of operation, and produced a new and different result.

(Pages 18-19):

In both of the English cases the very question of law and fact at issue (and on which the question of infringement turned) was whether the novel procedure of petitioners' inventors, involving, as it did, the employment of a minute and almost infinitesimal quantity of oil in conjunction with vigorous agitation, introduced a substantially new mode of operation and produced a substantially new result when compared with

the prior Elmore processes, in which a relatively large and substantial quantity of oil was employed.

Similarly in the case before the Circuit Court of Appeals the very question at issue (on which the question of patentability necessarily turned) was whether the novel procedure of petitioners' inventors, involving, as it did, the employment of a minute and nearly infinitesimal quantity of oil in conjunction with vigorous agitation, introduced a substantially new mode of operation and produced a substantially new result when compared with the oil processes of the prior art, in all of which a relatively large and substantial quantity of oil was employed.

Main Brief, Final Hearing in Supreme Court.

(Pages 1-2):

The distinctive feature of the invention patented is the employment of air bubbles in co-action with a minute and critical amount of oil in a mixture of ground ore and water so as to produce upon the surface of the water a froth containing substantially all of the metallic particles which can be easily flowed off or removed.

This process was never used before. This result was never obtained before. The process is dependent upon the use of oil in a minute and critical amount and thorough aeration. If more oil is used, you do not operate the process, and you do not get the result. So also if less oil is used the process is not operated, and the result is not obtained. By using other and greater quantities of oil you operate a different process and you obtain wholly different results. That the critical amount of oil characterizing the process is a minute amount of oil (varying slightly with different ores and different oils) is merely a fortuitous circumstance. Nevertheless the process is dependent upon such definite minute amount of oil. Obviously therefore it cannot be said that the use of the minute amount of oil characterizing the process in suit, as compared with prior disclosures suggesting the use of greater amounts of oil, is a mere improvement in degree suggested by the desire to economize in the use of oil, since every prior disclosure with which the process may be compared was wholly different in characteristics and essential mode of operation and principles involved and result obtained. The process of the patent in suit evokes new principles, employs a new mode of operation, and produces a new result, not theretofore evoked, employed or produced.

(Pages 6-7):

The secret of the invention of the process in suit was the discovery that by the agitation and aeration of an ore pulp (water and finely ground ore particles, the water when in motion carrying the ore particles in suspension therein) in the presence of a mere trace of oil such that the metal particles were coated with a thin attenuated coating of oil, so thin as to be imperceptible to sight or touch and so attenuated as to exhibit none of the known properties of oil, air bubbles would be produced and controlled and made persistent that would firmly attach themselves to the metallic particles and by their buoyancy float the heavy metallic particles upward to and through the surface of the pulp, and form above and resting upon the surface of the pulp a floating layer—usually several inches in thickness—of a mineral froth constituted of such air bubbles carrying the metallic particles. This was accomplished in practice by the employment of oil in the minute proportion of one-tenth of one per cent. on the ore.

(Page 9):

The process of the patent in suit is commonly known as the flotation process, although it is often more specifically described as the agitation froth process. In carrying it on the ore is ground to a fine powder, finer than ever before, and thereby reduced to separate particles of valuable metal or metalliferous mineral (usually the sulphides of metals) and of worthless rock or gangue. These ground ore particles are mixed with a considerable amount of water so as to form a freely flowing pulp (four or five tons of water to one of ore). An oil is added in the singularly minute quantity or trace above stated, about one-tenth of one per cent. of the weight of the ore (two pounds of oil to a ton of ore

in about four or five tons of water, constituting five or six tons of ore pulp), . . .

(Pages 10-11):

This latter fact, namely, that the process is in each instance conditioned on the use of definite and astonishingly minute oil proportions (varying slightly with different ores and different oils), is one of the important facts that is clearly proved in the evidence in behalf both of complainants and of defendant which the Circuit Court of Appeals overlooked or disregarded. Defendant's foreman, after conducting defendant's process for many months, testified for defendant as to the working instructions received by him from defendant and which governed his operation of the process as follows:

> "I was instructed by Mr. Hyde as to the regulation of the supply of oil . . . to use oil . . . in such quantity as to produce the best result. I was told that the use of too much oil is indicated by a flat film on the surface of the water, the mineral forming globules and sinking; . . . that when too little oil is used, there is no separation of the minerals and waste." (R., Gibson, p. 75.)

From the above evidence of defendant and other abundant evidence in the record it appears that for a given ore and a given oil, a definite minute amount of oil is essential to the carrying on of the process; that any substantial increase or diminution of this critical quantity of oil impairs or destroys the process; and that the production of the peculiar mineral froth characteristic of the process is recognizable by metallurgists skilled in this new art as an infallible indication of the use of the process . . .

(Pages 11-12):

In the opinion of the Circuit Court of Appeals in the case at bar patentability is denied to this invention for the stated reason that a reduction in the quantity of oil from that of prior disclosures is a mere matter of *degree*. This rests upon the assumption that the result obtained by the process of the patent in suit could have been obtained in the processes made known by prior disclosures, and that the only novelty of the patent in suit was the economical use of oil. This assumption has nothing whatever to rest upon and all the evidence in the case shows it to be a false assumption.

(Pages 12-13):

ERROR OF LAW IN THE OPINION OF THE CIRCUIT COURT OF APPEALS.

These errors of law may be summarized as follows:

1. In holding that the process of the patent in suit was devoid of patentable novelty, although admittedly novel in the matter of the minute quantity of oil used, and although admittedly highly useful and in extensive use, and although none of the alleged anticipating disclosures described a flotation process which had achieved any usefulness in the practical art.

2. In holding that the process of the patent in suit was a mere matter of economy in oil and followed naturally and without invention from what was previously known in the art; and in overlooking in that connection the testimony in the case which showed that all efforts to reduce the quantity of oil in prior commercial oil processes were failures, except in the Cattermole metal-sinking process, and that the patentees' efforts to economize oil in that metal-sinking process suddenly,

upon reaching a critical point of minuteness of oil quantity employed, reversed the entire phenomena, evoked opposite and unexpected and not even yet fully understood principles of action and modes of operation, and delivered the metal values at the top in a floating froth, the like of which for practical metal concentration purposes had never been known before.

(Page 15):

The Circuit Court of Appeals in its opinion says of the processes disclosed in prior documents and the process of the patent in suit:

> "The evidence in the case, together with the illustration thereof afforded by demonstrations of the various processes which were made in the aid of the argument before this Court, convince us that the froth in all these processes is the same, with the exception that there is *less oil* (*as there must necessarily be*), in the appellees' froth than in the others. The froths are all similar in appearance, they all rise to the surface after the same amount of agitation, they all gather with equal efficiency the same quantity of metal, and all may be removed from the surface in the same way." (R., pp. 720, 721; italics ours.)

It is respectfully submitted that the evidence in the case furnished no foundation whatever upon which to base a conviction "that the froth in all these processes is the same." The undisputed fact, so far as the evidence in the case is concerned, is that the metallic froth produced by complainant's process is unique and characterizes such process and distinguishes it from all other previous processes.

(Pages 36-37):

These theories of Professor Pollock which were accepted by the Privy Council as to the function performed by the minute proportion of oil used in the agi-

tation froth process, are acceptable today and upon the record herein, and it is only necessary to add to them the fact that the minute quantity of oil, besides performing the function of maintaining "extremely minute emulsion" and producing "permanency in the froth" or persistency of the air bubbles, coats the metal with a film so attenuated as to be almost infinitesimal, and mysteriously acts so as to increase the mutual attraction of the air bubbles with metallic particles and to cause them to persistently hold together in the rush and swirl of the agitation and until the froth has overflowed from the surface of the liquid and separately delivered the metallic particles; and that this operation takes place notwithstanding the fact that any substantial increase in the oil proportion above the critical minute proportion required with a given oil for a given ore destroys the operation of the process and produces a useless mode of operation approaching that of Cattermole in that the metallic particles tend to stick together and sink.

(Page 41):

The manner of conducting such simple preliminary tests, as they are being made every day in the laboratory of the complainants, and for that matter in the laboratories of the licensees, since every plant includes a laboratory to guide and check the larger operations of the mill, is described in the evidence (R., Chapman, pp. 191, 192). It will be noted that this description closes with the statement:

> "The greatest amount of oil that I have ever used in practice is 4 lbs. per ton of ore, and the smallest amount I have ever used in practice is one pound of oil per ton of ore." (R., p. 192.)

(Page 47):

Dr. Charles F. Chandler, who has educated more mining engineers than any other man and has been called upon to testify in all the principal metallurgical controversies for the past forty years, also describes this froth first produced by the process in suit (R., p. 382). At the conclusion of this description he says:

> "The oil has entirely disappeared from sight and sense. It cannot be seen and it cannot be felt, and the particles of mineral are just as bright as though there was no oil upon them at all." (R., p. 382.)

(Page 55):

Claim 9 is the broadest claim. The amount of oil is stated to be "a small quantity." The process is stated to include "coating the mineral with oil in water containing a small quantity of oil, agitating the mixture to form a froth, and separating the froth." The essentials of agitation of the ore in powdered form diffused in water in the presence of a small quantity of oil so as to form a froth and thereby to utilize air bubble separation, are set forth, as well as the completion of the operation of concentration or separation by separating the froth. The novelty of the invention as thus defined is unquestionable. Conditions may well arise in the future wherein the critical oil proportion is increased by reason of a useless absorption of the oil within the pores of a gangue material, or wherein an oil or a mixture of oils is employed having unusual characteristics, as a result of which the critical oil proportion may be one per cent. or slightly more. Under such conditions this and the two following claims may be necessary to protect the invention.

(Page 65):

He further testifies:

> "This plant was completed and adjustment runs made in or about April, 1905. . . . The oil consumption alarmed our clients, and I was instructed to use every endeavor to bring this down. This was only possible to the extent of .8% of the weight of the ore. The formation of good shotty granules was impossible under these conditions, mineral flocks being formed, and these readily separated on the skin flotation table. . . . The plant proceeded to run on these lines" (R., p. 186).

It will be noted that this effort by Mr. Chapman to economize oil consumption by spoiling the Cattermole process and producing a hybrid skin or film flotation process was carried on one month after the invention of the process here in suit, but in the Antipodes and in ignorance of the discovery of the process in suit, as will later appear. But even this use, subsequent to the present invention, with oil in the proportion of a large fraction of one per cent. of the ore, did not produce the floating froth, for had it been produced it would have gone to waste in the first upcast with the gangue slimes.

(Page 67):

It further appears that as to the seventh factor the actual instructions were to reduce the quantity of oil "step by step" (R., Ballot. p. 167), so as to find "the lowest limit at which results could be obtained by the use of oil" (R., Higgins, p. 180, last two lines). The work of Mr. Higgins under the supervision and direction of the inventors with all the factors that had been assembled in the researches of more than two years and a half as to the Cattermole process, and under particular and explicit instructions to reduce the oil step by step and note the results, brought about the discovery of the process of the patent in suit.

(Pages 70-71):

As to what was done under these instructions we have Mr. Higgins' report of March 16, 1905. The opening sentence of this report is as follows:

> "The effect of diminishing the percentage of oleic acid is to alter the type of oiling; the higher percentages producing granules, and the lower ones froth" (R., p. 448).

This is the first mention of froth in all of the reports. The writer's mind is evidently now directed away from metal sinking and towards this new process in which the metal floats in froth. Tests with oleic acid at from 3% on the ore downward are described, with no useful result in flotation, until suddenly with the oil at .32% on the ore the result is described as "float vastly increased," and with a further reduction to .1% on the ore we find again, as compared with what has gone before, "float vastly increased" (R., p. 448). This is the oil proportion recommended in the patent in suit.

(Pages 71-72):

. . . Thus the experiments were carried to the vanishing point and between that point and the minimum previous practice in the granulation process, to-wit: with oleic acid one and one-half per cent. on the ore (R., p. 445, *p. 891) was found this unexpected and startling phenomenon, the flotation of the metalliferous mineral in the form of froth. The experiments started with a metal-sinking process, dependent for its utility upon the agglomeration of metallic particles into granules of sufficient size to sink readily and certainly in an up-current which would carry away all the gangue particles. As the proportion of oil was diminished granulation became progressively poorer, and in fact disappeared. Then came the new phenomenon, with

new principles of operation and a new result. This attained its maximum when the oleic acid was present in the proportion of .1% on the ore.

(Page 74):

. . . In the process of the patent in suit this stickiness has disappeared altogether and does not interfere with the subsequent separation by physical treatment, although it may well be a factor in a subsequent chemical treatment. As above noted, the opinion of the Circuit Court of Appeals criticizes the invention and apparently declines to accept the proved fact that it is unnecessary to remove the oil from concentrates produced by the process of the patent in suit for subsequent physical treatment. . . .

(Pages 89-90):

During the progress of the suit the defendant's first plant was replaced by another apparatus substantially the same (R., Hyde, p. 95), and in it the same process was carried on. . . . Then he increased the cotton-seed oil to seven times the customary feed of oleic acid and also added "a few per cent. proportionate to the cotton-seed oil, of the 'red oil' " or oleic acid, and says he obtained good heavy froths and clean tailings, but in the absence of analyses or even samples of what he obtained, this may be doubted. If he did, however, he may have carried on the process first made known to the world by the patent in suit with something more than one per cent. of his peculiar mixture of oils, thereby accentuating the importance of those claims which point out the process without exact limitations of the amount of oil used, to-wit: claims 9, 10 and 11. The one thing that he did not do is significant. He did not vary the feed of the oleic acid alone, or, if he did, he does not tell us what results he obtained.

(Pages 196-197):

IMPRACTICABILITY OF METAL FLOTATION WITH QUANTITIES OF OIL LESS THAN ELMORE AND GREATER THAN THAT OF THE PROCESS IN SUIT.

With the use of oil proportions, between those of the Elmore oil-buoyancy flotation process (with its minimum of 100 per cent. of oil, or 2,000 pounds of oil to the short ton of ore and 2,240 pounds of oil to the long ton of ore), and the process of the patent in suit (with its minute oil proportions varying slightly for different ores and different oils, but never in practice greater than .18 per cent., or four pounds of oil to the long ton of ore and 3.6 pounds of oil to the short ton of ore, and averaging .1 per cent. or 2.24 pounds to the long ton of ore and 2 pounds to the short ton of ore) there is only one practical process of ore concentration and that is the Cattermole metal-sinking process. This is established by the history of the art of ore concentration as proved in the evidence, and by the careful consideration in the evidence of all prior documents.

It is proved that the admittedly novel minute oil proportions of the process in suit are critical proportions, invariable with a given oil and a given ore. The following testimony of Mr. Chapman, who installed and operated the process of the patent in suit in Australia, Finland, Sweden and Wales, as to this point, is uncontradicted:

> "110 Q. What has been your experience when, in using the agitation-froth process on a commercial scale, with a normal and proper consumption of one and a half pounds of oil per ton of ore, this procedure has been varied by increasing the oil feed to two and a half pounds per ton of ore?
>
> "A. The mineral froth being produced on the

spitz boxes loses at once some of its natural color and lustre and becomes dull in appearance. The quantity of froth being recovered on No. 1 box is considerably lessened. The froth on No. 2 spitz is slightly increased and the same with No. 3 box. The tailings on examination immediately show increased losses of sulphide mineral. These losses take the form of well oiled agglomerations.

"111 Q. And what has been your experience when the normal and proper feed of one and a half pounds of oil per ton of ore has been diminished to half a pound of oil per ton of ore?

"A. The froth being recovered immediately diminishes in quantity and the color shows the presence of slime gangue. The supporting liquor of the spitz box immediately changes in appearance and shows the natural color of the ore slimes. The tailings become very dirty and show no sign of what we know as a good 'clean up.' In fact the whole treatment suffers and unless the oil feed is restored to its normal condition a serious drop in recovery takes place with the production of a lower grade concentrate" (R., pp. 195, 196).

This evidence is not only uncontradicted, but corroborative of the evidence in behalf of the defendant of defendant's foreman, who, in describing the rules which governed his operation of defendant's infringing process, said:

"Too much oil is indicated by a flat film on the surface of the water, the mineral forming globules and sinking. . . . When too little oil is used, there is no separation of the minerals and waste" (R., Gibson, p. 75).

(Page 198):

. . . Notwithstanding this obvious fact, however, the defendant has endeavored to prove by laboratory tests in the slide machine that it is possible to concentrate ores by metal flotation with the employment of such oil proportions as are disclosed in prior documents. Additionally it has been falsely represented that

these laboratory operations carried on in the test machine of the process in suit (this test machine having been invented in 1909) and with the utilization of all the knowledge that has come to the art by reason of the process in suit, are representations of the disclosures of these prior documents, as is indeed necessary to give to these demonstrations any evidential value in behalf of the defendant; but as to this enough has been said in the chapters devoted to the respective prior documents.

In behalf of complainants, for the information of the court, tests were carried out, first, in a miniature of a commercial plant, used for testing purposes, and, then, in a small commercial plant, and the procedures in the slide machine with the amounts of oil in excess of the critical proportions of the process in suit were found to be hopeless and useless in anything approaching practical operations.

(Page 199):

Tests were also made by Mr. Chapman at London in the standard 50-ton plant with the only ore available there in sufficient quantity, Broken Hill tailings (R., p. 388), with cotton-seed oil in the proportion of 3.6 per cent. of the ore and oleic acid in the proportion of 1.8 per cent. of the ore. These tests are fully described and the results as shown by analyses set forth (R., pp. 388-392). The amount of metal lost in the tailings in the three tests with 3.6 per cent. of cotton-seed varied from 68 per cent. to 86 per cent.—an absolutely hopeless operation. The tailings contained granules and the granules from the tailings of test No. 2 are in evidence as "Complainants' Exhibit, Cattermole Granules Chapman London Test." Test No. 4, with 1.8 per cent. of oleic acid, was not so bad in loss of metal, which was

about 30 per cent., but the concentrate contained so much gangue "that it would not really be considered a concentrate" (R., p. 795).

(Pages 199-200):

. . . These tests made it quite clear that the laboratory operations carried on by Dr. Byrnes and alleged to represent processes of ore concentration were wholly incapable of producing any useful result in practice, and that the larger the plant the worse the result. Of course, the burden was on the defendant to show practical ore concentrating operations, to demonstrate that the verdict of practical men of the art in rejecting the procedure disclosed in prior documents was an erroneous verdict. Unable to prove practical use in the art of any of these paper processes, the defendant should at least have proved that they were capable of practical use.

(Page 203):

As to the finding by the Circuit Court of Appeals that the invention was merely a matter of degree—"a difference of degree and not of kind"—(R., p. 719), it is submitted that the evidence is conclusively to the contrary. As above noted, an increase in the quantity of oil above the critical proportions of the process in suit destroys the process. So also diminution in the quantity of oil destroys the process. The proper proportions are highly economical, but the process is as much dependent upon them as if they were prohibitively expensive. The economy of oil consumption is a highly meritorious feature of the invention, but the invention should not be condemned because of its merit in this particular.

(Page 204):

In prior efforts oil was the selective and separating agent and was an apparent factor throughout the procedure. The process in suit utilizes oil, it is true, but utilizes it as a bubble and froth controlling agent. The real flotative agent is air, functioning in the presence of a minute quantity of the oil or frothing agent, and the oil disappears from sight and touch, and does not prevent but to the contrary assists the firm attachment of the air bubbles and metallic particles.

Commenting on Judge Bradford's opinion, plaintiffs' counsel said in this brief:

(Page 254):

The question of invention. Judge Bradford had before him by stipulation the identical London evidence which was taken in the case at bar, with omission only of the matters personal to the defendant Hyde. His conclusions, therefore, from the facts and circumstances connected with the discovery of the process here in suit, were founded upon the record in that respect which is before this court. He also had before him all prior documents referred to in the opinion of the Circuit Court of Appeals in the case at bar, and also two prior documents not in evidence in the case at bar. His consideration of the question of invention commences at page 10 of his opinion. He says, in part:

> "There was, I think, patentable invention in the discovery thus made in March, 1905. Prior to that time there had been no suggestion in the art that the proportion of .1% of oil to ore or of any other fraction of 1% of oil to ore would or might result in successful concentration. Further, the result reached was an utter surprise. Experiments were conducted with reference to the Cattermole process, and all of the Cattermole patents required the formation and sinking of granules containing the

metallic particles, and not their flotation. The teaching of that process was that the metallic particles should go to the bottom and that of the process of the first patent in suit that they should go to the top'' (*idem,* p. 14).

(Page 256):

Judge Bradford then further says:

"... The patentability of the process of the first patent in suit resides in the use of only the minute quantity of oil contemplated by the patent. The reduction of the oil to this quantity effected a change, not merely in the degree, but in the 'type of oiling,' leading to results which cannot be accounted for on the assumption that a mere change in degree as distinguished from patentable discovery was involved'' (*idem,* p. 17).

(Page 258):

Claim 9. It will be noted that although Judge Bradford finds that the process is dependent on the extreme tenuity of the film of oil on the metallic particles and that the selective action is due to the air bubbles and that the process is "an air flotation process," he nevertheless limits the breadth of the claims to the carrying on of the procedure with the employment *in the pulp* of a fraction of one per cent. of oil on the weight of the ore.

(Page 259):

Claim 9, we submit (as well as claims 10 and 11, where the same language is employed), should be construed to save them rather than to destroy them (*ut res magis valeat quam pereat. Corning* v. *Burden,* 15 How., 269), in spite of the presence of other claims. Limiting words (as of degree) in a claim should be construed in the light of the disclosure made in the specifi-

cation and in the light of the real invention (*Carnegie Steel Co.* v. *Cambria Iron Co.,* 185 U. S. 403, 432. Robinson on Patents, Vol. II, p. 507, Sec. 751). So construed, claims 9, 10 and 11 would be limited to that small quantity of oil which is described in the specification and which would in use develop the operation and effect described and would embody the invention.

Petitioners-Complainants' Reply to Brief for Respondent.

(Page 1):

Brief for respondent presents a fictitious case and not the case presented by the record.

A fundamental fiction, and one which it is imperative for him to establish, is that with quantities of oil greater than the minute quantity characterizing the invention in issue, agitation will evoke the same principles of action and produce the same metallurgical results.

(Pages 3-5):

If the language of Lord Parmoor were susceptible of any such inferences as the respondent draws therefrom, the impossibility of such inferences being warranted is made entirely manifest by adverting to "question 5780 and the following questions," to which he refers. They are as follows:

(Page 473, Printed Record in the Privy Council, No. 7 of 1912. On appeal from the Supreme Court of New South Wales in its equitable jurisdiction between The Ore Concentration Company (1905), Limited, and Australasian Ore Concentration Syndicate, Limited, (Plaintiffs), Appellants, and Sulphide Corporation, Limited (Defendants), Respondents.)

> "5780 Q. Mr. Irvine: Now, I am going to ask you one or two questions with regard to the application of what you have been saying to the particular issues in this case. You have given us this selective action, if I may use such an expression, of bubbles as bubbles. You have told us of the increase of the selective action of these bubbles by the addition of a little acid, and you have pointed out the two functions which you say, in the defendants' process, or a process similar, are performed by the minute quantity of oil introduced; the two functions being the permanency of the froth, for the well rec-

ognized scientific reasons you have explained, and the other the extremely minute emulsion which is introduced in that case, but not where there is no oil. Now, I want to ask you, is there necessarily any other function performed in the defendants' process by that small quantity of oil introduced? A. I do not think so.

"5781 Q. It has been suggested—in fact it has been stated very distinctly by some of the witnesses—that even with that extremely minute quantity of oil there must necessarily be a greasing or oiling of all the metal particles. What do you say with regard to that? A. The oil may be in excess and some of the particles may get oiled, but in my opinion, it is quite unessential—entirely and absolutely unessential.

"5782 Q. First of all, with that minute quantity of 1½ lbs. of oil, say to the ton; is it possible to affirm that there is more oil introduced than is necessary for the concentration you have been speaking about? A. I do not think so.

"5783 Q. Mr. Irvine—or filming purposes? A. I do not think so, because it would be impossible to calculate the entire surface of the enormous number of bubbles.

"5784 Q. You could not affirm in fact, whether there is or is not a surplus of oil? A. I do not think so.

"5785 Q. Unless you can somehow approximately measure the surface of all the multitudinous bubbles in that emulsion? A. Yes.

"5786 Q. Well, it has been further stated that the selective action—that is the picking out by the air bubbles, or gas bubbles, of the metallic particles from the gangue will not take place unless those metallic particles are greased. What do you say to that? A. I do not agree with that at all.

"5787 Q. You do not agree with that? A. No.

"5788 Q. And that is why you say the greasing is quite unessential to this process. A. Yes, if it occurs.

"5789 Q. Whether it does or does not occur, as I understand you, must be a matter of conjecture?

"A. Yes."

(Page 5):

It is luminously clear that Prof. Pollock did not testify that ore concentration or concentrate froths could be formed by the use of more than one per cent. of oil; it is clear that testimony that such concentration could be effected by "from less than 1 per cent. to 25 per cent. by weight relative to the ore treated" is not in accord with Prof. Pollock's testimony as respondent asserts.

(Page 6):

II. In support of the proposition that "ores that can be floated with less than 1 per cent. of oil can be floated with more than 1 per cent.," respondent's brief cites the testimony of Mr. Nutter, chief engineer of Minerals Separation, Limited, pages 63 to 66, where he sets out the customary procedure in the treatment of a new ore, and, among other things, speaks of altering the quantity of oil in adjusting to new conditions.

But the alterations in quantity of oil referred to by Mr. Nutter were minute alterations, all well within the limits of the quantity specified in the patent in suit. It is the astonishing fact that, so far as the record here shows, with every ore the world over to which the process has been applied and with all the varying conditions of use, the largest quantity ever used has been 4 pounds to the long ton (*i. e.*, less than 2/10ths of 1 per cent.), and that the smallest quantity has been 9/10ths of a pound per long ton of ore (*i. e.*, less than ½ of 1/10 of 1 per cent.). (See Brief for Petitioners-Complainants, pp. 41 and 42.) The defendant uses 3.2 pounds of oil per ton of ore (*i. e.*, .16 per cent of the oil—less than 2/10ths of 1 per cent.). (See Brief for Petitioners-Complainants, p. 88.)

It is such alterations in quantity of oil as these that Mr. Nutter referred to. Respondent's deduction from his testimony is wholly unjustified.

(Pages 6-7):

III. Respondent's brief, in support of the proposition that the process of the patent in suit proceeds when the quantity of oil is more than 1 per cent., cites the evidence of Mr. Higgins, the metallurgist engineer for Minerals Separation, Limited, . . .

But reference to the record, page 387, shows that Mr. Higgins' testimony has been misrepresented. The froth produced, he says, did not differ in appearance from the usual agitation froth at a distance of a few feet, "though oily in appearance when closely examined." "These floats were exceedingly dense and occasionally fell down in large masses. The tailings contained some granules, and did not indicate a satisfactory recovery." It also appeared that the recovery was only 50 per cent. of the zinc, which means that 50 per cent. of the zinc was being thrown away in the tailings—a useless and hopeless result. He further testified: "This plant is not intended for commercial use in treating zinc ores, being only a testing plant."

(Pages 8-9):

V. Respondent's brief, on pages 46 and 47, refers to certain floating froths or oil magmas produced in the laboratory by the defendant, James M. Hyde, and his expert, Dr. Eugene A. Byrnes, with quantities of oil ranging up to 25 per cent. of the weight of the ore, as evidencing that the same result obtained by the process of the patent in suit may also be obtained by the use of such larger quantities of oil.

But these tests do not support the conclusion drawn

from them. They never went beyond the laboratory. There is no evidence that they would be of the slightest utility in the mill, or that they could ever be carried out practically in the mill, or that they were in any proper sense metallurgical processes for the concentration of ores.

There is no evidence to indicate that any such processes were ever used with any practical success in the mill. There is affirmative evidence to the contrary.

(Page 9):

It is in the highest degree significant that the respondent, instead of demonstrating the practicability in the mill of a process of ore concentration involving the use of notable quantities of oil, as it could perfectly well have done, if any practicable process of that kind existed or were possible, contented itself with the legerdemain of the laboratory, wholly inconsequential even at best in its implications, and stands here and now upon misrepresentation of the testimony of petitioners-complainants' witnesses and of the Privy Council decision.

Oral Arguments Before the Supreme Court.

(Pages 8-9):

Mr. Williams: I have tried to picture the process. The process is today a mystery so far as complete scientific explanation is concerned. We cannot explain why the little air bubble holds on so tightly to the metallic particle. The presence of a minute amount of oil, we know, keeps the bubbles little, or makes them little. We know it makes the little bubbles persistent, practically permanent, so that they rise up through the water without coming together and forming larger bubbles, and when they get on top they stay there. Apparently they will stay there forever without bursting. We know that the minute amount of oil that we use does those two things, makes for very small bubbles and for persistency in the bubbles and froth.

. . . We know that air bubbles have a strong affinity for metallic particles, and we know also that oil in any more than our quantities destroys that attraction of the air bubble to the metallic particle. We know that, but why the minute amount of oil adds to the attraction of the bubble and the metallic particle, we do not know.

(Page 10):

The Cattermole process uses so much oil that the metal particles will stick together. Pursuing a line of investigation for the purpose of improving that process in all its factors (and those facts were violent agitation and the use of heat, the use of acid, sulphuric acid, used only for its physical effect, and the use of an oil, but in such proportion that it made the particles stick together), we said: We will now reduce the amount of oil and under these conditions that we have assembled

we will keep on reducing and see what happens. We kept on reducing it and suddenly the process changed. Instead of the particles going down they rose in a great black froth. That was the discovery, although we cannot explain it today.

(Page 12):

The amount of oil that we use is generally one-tenth of one per cent. on the ore; two pounds of oil to the short ton of ore. Every ore presents its own problem, but for a given ore and a given oil there is a certain critical factor. The variations in that factor in practice have been from a trifle less than one pound of oil to the long ton in the case of the rich ores of Australia to four pounds of oil to the long ton in the case of a lean copper ore at the Braden mines in Chile. Those are the variations of different oils and different ores, and because of those minute variations you have the impossibility of saying that this process always uses just so much; but given any ore and given any oil, the evidence shows that if you add another pound of oil your metal particles commence to stick together and commence to fall down in granules, and you get into the Cattermole sinking sphere, whereas, on the other hand, if you diminish it, you cease to have that selective action which is essential; you do not get any float in particular and you have gangue in it; so that it is critical for a given oil and a given ore, but it has variations.

(Page 13):

Mr. Justice Day: Let me understand you. What do you claim is the invention you made inasmuch as oil was used for this purpose before your invention? Just what is the step you take that you claim constitutes invention?

Mr. Williams: The step that we took was the use of a minute amount of oil as compared with anything that went before, associated with such conditions that the air bubble was capable of doing its work.

Mr. Justice Holmes: All previous methods were by sinking and this one is by flotation?

Mr. Williams: That is not wholly true. The Elmore oil buoyancy, with a ton of oil to a ton of ore, floated. Then the Cattermole sunk, using a proportion of oil which at its very minimum was 1½ per cent., or 30 pounds to the ton of ore, a sufficient amount of oil to moisten the metal particles so that they would stick together.

Mr. Justice Day: You greatly reduce the amount of oil. What else did you do? I would like to understand the operation.

Mr. Williams: As compared with Cattermole, we greatly reduced the amount of oil and nothing else—as compared with Cattermole, a metal sinking process.

(Page 16):

Then came Cattermole. Cattermole is a process of sinking wherein you use as a minimum one and one-half per cent. of oil, or thirty pounds of oil to the short ton of ore, but Cattermole is particularly and specifically described as a process that cannot be used with lean ores.

(Page 21):

Now, Professor Pollock's testimony, as summarized by the Privy Council: "He allows that there may be oil in excess" of what is necessary for permanency of froth and extremely minute emulsion within this minute proportion of two or three pounds to the ton, "and that some of the particles may get oiled, but states that

this is entirely and absolutely unessential"; that is to say, with two or three pounds of oil to the ton of ore he thought that oil just did the work of making permanency and minute emulsion, and that it did not necessarily coat the metal; but if it did coat the metal, then the part that coated the metal was an excess; that was the sense in which he used the word "excess." If some little fraction of that minute fraction did coat the metal, why it was absolutely unessential to his theory.

> "He does not, however, think that more than the necessary quantity of oil is introduced to effect concentration, but that having regard to the nature of the problem it is a matter of conjecture, and exact calculation is not possible. Finally, he reiterates his opinion that the defendant's process can be accounted for without assuming selection of the metallic particles by oil."

We are in entire agreement with him that selection of the metallic particles by air bubble is a characteristic thing of the process, but we disagree with Prof. Pollock as to the fact that the particles may or may not get oiled. We say we are quite sure that the particles do get oiled with this minute attenuated coating.

(Pages 33-34):

. . . As to Everson and Kirby, they did not give us any assay, and the evidence shows nothing. But as to a procedure which at one time was called Froment and at another time Schwarz, they gave us an assay, and they did get up a fair amount of metal within the walls of this little test machine of ours. That had never happened before. Under the conditions under which they carried it on, there should have been a Cattermole operation, but they managed, by the very intensity of their agitation, to prevent granules from sinking, and, perhaps, by the brevity of their agitation, to prevent

the granules from forming. So they got a float which had never been obtained before, and it surprised us, and we said: We will carry out these operations on a larger scale and see what happens. It is true it is the invention of the defendant's expert. It is not a part of the prior art, but for the information of the court we will carry it out on a larger scale. So we had Mr. Higgins carry out the same operation, practically the same, with 3.6 per cent. of oil, in a little testing plant which was available at the mines of Senator Clark in Butte, Montana. It was only a little plant. It was not a full size operation. In that operation he lost 50 per cent. of his metal. He said that it fell down in bunches when it spread out on the surface of the spitzkasten, and although at a little distance it looked like our floating froth, on close inspection it was found to be an oily floating mass. It fell down in bunches, and it only saved 50 per cent. of the zinc and threw away the rest of it. But we were not satisfied with that. We took the smallest full-size plant, the 50-ton plant, through which 50 tons of ore are carried by 200 tons of water in twenty-four hours, and we carried out an operation in that, and there the loss was 82 per cent. It was hopeless. So that we demonstrated the negative of the proposition that the defendant had failed to demonstrate. We demonstrated that these products of the legerdemain of the laboratory, not prior art at all, were worthless in the concentration of ores, wholly regardless of the question of the cost of oil or anything else.

Argument of Mr. William Houston Kenyon in Reply for Petitioners-Complainants.

(Page 84):

Another line of investigation was as to the influence of changes in the amount of oil (page 447, the seventh item). Out of that series of experiments (where the only change made from experiment to experiment was in the amount of oil—a gradual diminution in the amount of oil, all other things remaining the same) was born this invention.

And the record of it is right there on page 448, "Details of Experiments," the last column, "Remarks," "Float vastly increased"—tracing that back you see it was with three-tenths of one per cent. of oil; and just below "Float" again "vastly increased"—tracing that back it was with one-tenth of one per cent. of oil.

This float phenomenon appeared (page 451) when the oil had been reduced to about one-half of one per cent., said the inventors, after studying the process six weeks.

As the amount of oil was reduced granulation practically ceased at a range of about one-half of one per cent. of oil, but a certain amount of black mineral froth was noticed. They were trying to send the values down, but they began to come up to the top.

Mr. Justice Day: Is that on page 451?

Mr. Kenyon: Page 451, the third paragraph.

> "A certain amount of black mineral froth was, however, noticed as a result. On successively decreasing the amount of oleic acid below .5 per cent. [that is one-half of one per cent.] it was found that whereas granulation ceased there was a growth in the amount of mineral float-froth under these conditions, and that the production of such float froth appeared to reach a maximum when about .1% of oleic acid on mineral was used."

If that evidence is true, it disposes of the contention that this phenomenon which has revolutionized ore concentration the world over is to be explained as some trick of agitation.

(Page 85):

MR. JUSTICE MCREYNOLDS: I would like to ask you when in this process of reducing oil your invention came into existence?

MR. KENYON: At about one-half of one per cent. of oil.

MR. JUSTICE MCREYNOLDS: Before you got to the one-half of one per cent. did you have any invention?

MR. KENYON: We were passing from the region of Cattermole, which was a distinct——

MR. JUSTICE MCREYNOLDS: I want to know when your invention came into existence?

MR. KENYON: This invention was not reached, I should say, from those figures, until about .5, that is, one-half of one per cent., of oil was reached.

MR. JUSTICE MCREYNOLDS: At one per cent. you had no invention?

MR. KENYON: No.

MR. JUSTICE MCREYNOLDS: At one-half of one per cent. you did have invention?

A. It began to come. Remote, but it began to come. At .3 of one per cent. the float vastly increased. At .1 of one per cent. the float again vastly increased.

MR. JUSTICE MCREYNOLDS: When this float has more than one-half of one per cent. of oil it does not infringe?

MR. KENYON: It does not infringe.

MR. JUSTICE PITNEY: What have you to say in answer to what Mr. Scott said the other day to the effect

that 1.8 per cent., or perhaps more, of oil would give the same result with increased agitation?

MR. WILLIAMS: Absolutely no.

MR. KENYON: It would not.

MR. JUSTICE PITNEY: I understood him to say so yesterday, and I suppose there was something in the record to justify it.

MR. KENYON: Nothing. That will be a part of my argument.

(Pages 86-87):

In this froth the metal values are carried by myriads of minute air cells whose walls are constituted of persistent films of water contaminated by a mere trace of oil. (Record, page 235, at the middle.) The oil is invisible. The color of the metal gives the color to the froth.

If a larger quantity of oil be added to the pulp, for example, two or three per cent., the Cattermole effect appears. With the same identical agitation the oiled metal particles agglutinate and sink. The values are taken away at the bottom. This larger quantity of oil on the metal particles destroys the attraction of those particles for air cells, as evidenced by the fact that air is beaten into the pulp in the Cattermole agitation just the same as in the identical agitation in the process in suit, but it does nothing and escapes and, in spite of it, the values go to the bottom.

MR. JUSTICE HOLMES: That is the formation of globules.

MR. KENYON: The formation of globules. It utilizes the stickiness of oil.

If still more oil than Cattermole proportions be added to the pulp, too much to act as an agglutinant, the same agitation will beat it up into a pasty magma or oil

emulsion, no matter what the quantity of oil, entrapping air cells and metal particles, but having little affinity for either, and destroying their affinity for each other.

No such oil magma froth has ever concentrated ore successfully in the mill. Dr. Byrnes, defendants' expert witness, in 1911 (Record, page 118, at the bottom, and 119) says: No oil process of ore concentration was in use in this country at that time except defendants—and, I might add, that came from plaintiff.

These oil magmas or froths with any amount of oil can be readily produced in the laboratory. But they are mere laboratory freaks, absolutely useless in the mill. In the mill granules would tend to form and go to the bottom. The froth would be fragile and drop in great chunks. It would not hold onto the metal. It would be unreliable and uncontrollable.

(Pages 87-88):

If respondent tomorrow repeats the tests set out in his record, he will be doing what is nowhere shown in any part of the prior art, as our brief points out in detail.

MR. JUSTICE PITNEY: He will be doing what?

MR. KENYON: He will not be carrying out the processes of the prior art.

MR. JUSTICE PITNEY: What will he be doing?

MR. KENYON: He will be performing tests with large quantities of oil, just laboratory tests that he arbitrarily chooses to perform. He will give them the names of old processes; he will call them Everson, Kirby, Froment, but they will not be either of those three.

1. They will be carried on in modern machinery not known at the time.

MR. JUSTICE MCKENNA: Pardon me one question.

Will they be using more than one-half of one per cent. of oil?

MR. KENYON: Yes, sir; anywhere up to 25 per cent.

MR. JUSTICE MCKENNA: Yet they result in the production of a froth?

MR. KENYON: You will have an oily mass or magma at the top, but it will not do anything towards concentration of ores. I am coming right to that point now.

2. They will be carried on with a violence of agitation that was unknown to any of the processes of the prior art. Our brief at pages 211 to 216 points out the law that that is not the way to demonstrate prior processes, and this Privy Council case which has been referred to here is an English authority directly to the point——

MR. JUSTICE MCKENNA: How near will they get to the patent in suit?

MR. KENYON: It will be absolutely outside of the patent in suit.

3. Finally, such oil froth processes are absolutely not usable in the mill at all. To demonstrate that I want to turn to the evidence of Dr. Byrnes, for the defendant. I presume this will be one of the tests that will be shown you tomorrow. I do not know what it will be called tomorrow. Record, page 108. Second experiment Froment. 3.6 per cent. of cotton-seed oil agitated in our slide machine, about two pounds of the ore treated. Result: his tailings showed only one per cent. of zinc—wonderfully clean tailings; his recovery, as figured by Dr. Liebmann (page 299) was about 100 per cent. of the values—a remarkable recovery.

We followed identically the same process first in a seven-ton a day plant, a semi-commercial plant, and then in a fifty-ton a day plant, a full commercial plant —to see what would happen. We did just the things

there that Dr. Byrnes did in the laboratory. Mr. Higgins testifies as to the first at page 387 of the Record. Result: his tailings showed 12 per cent. zinc, and his recovery was only 50 per cent. of the values. Half of the values were gone. He says the float fell in masses; that the tailings had some granules (the Cattermole effect had been to some extent produced); that the recovery was not satisfactory.

(Page 89):

Mr. Justice McKenna: Your contention then is that the laboratory test is no standard.

Mr. Kenyon: Yes, sir; absolutely no standard whatever.

Mr. Justice McKenna: Do you admit that the laboratory tests show a similarity?

Mr. Kenyon: Yes. I cannot myself tell one float from another by visual observation. But the mill man will tell you the instant he tries to carry out the process in the mill.

Indeed even minute departures in the mill from the standard oil quantity needed for the particular ore are harmful, and I want your Honors to mark page 196 of our brief on that point.

Mr. Chapman was asked:

> "What has been your experience when, in using the agitation-froth process on a commercial scale, with a normal and proper consumption of one and a half pounds of oil per ton of ore, this procedure has been varied by increasing the oil feed to 2½ pounds per ton of ore?"

Note: This was only a small increase.

He says the tailings, on examination, immediately showed increased losses of sulfide mineral. The result was harmful.

Then he was asked, what if you diminish the oil to half a pound of oil per ton of ore? He answered:

> "The whole treatment suffers, and unless the oil feed is restored to its normal condition a serious drop in recovery takes place with the production of a lower grade concentrate."

And defendants' foreman, Gibson, testified (Record, page 75):

> "Too much oil is indicated by a flat film on the surface of the water, the mineral forming globules and sinking. . . . When too little oil is used, there is no separation of the minerals and waste."

(Page 90):

Mr. Justice McKenna: Are there any experiments on the other side showing more than laboratory tests?

Mr. Kenyon: No, sir. They stop with laboratory tests. Tomorrow you will see, but you will not know. The layman cannot tell the useful froth of the process in suit from a useless oil emulsion; whether it is a step in a real process of ore concentration or only a sham; whether it can be reproduced in the mill or not, or would treat or successfully concentrate ore. It is a situation for caution, especially as the court below was misled by just such demonstrations.

(Page 91):

4. It is apparent that the inventors in their minute one-tenth of one per cent. oil frothing reagent were really invoking a characteristic and a power of oil in an ore concentration process that develops only in that relatively microscopic quantity, and which is defeated and disappears when that minute quantity is even slightly exceeded, a characteristic and a power of oil which had not existed in the prior oil concentration

processes of the art, which had never been utilized by anybody for ore concentration, and the very existence of which had not been known or suspected. They were invoking the power of oil when present in microscopic amount to exercise the powers of the air to search out and find in the swirling vortex of the pulp, and hold on to through the seven or eight or ten minutes of agitation, and safely bring to the top, at the end, the valuable mineral particles and hold on to them there until they could be floated away. They harnessed the giant of the air to their task, and the oil was only curb and bit. It was a wholly new role for oil to play, a wholly new function for oil to perform, a wholly new combination of oil and air. That takes this process right out of the oil concentration art. It is not a process of oil concentration. It is a process of air concentration, as both the House of Lords and the Privy Council have held.

Reply Argument of Mr. Williams Before Judge Bradford, Miami Case.

(Pages 293-294):

THE COURT: I was going to ask this question:

This case has been argued and presented on the part of the complainant in such a way as to impress the court with the idea that it is contended that the reduction of the oil to very minute quantity brings about this startling result that has been referred to by counsel.

What I should like to get at, if it is possible, is, what are the limits claimed by the counsel? It seems to me to be very indefinite, and, of course, the statement is made that nobody understands exactly why it is; but there ought to be, it seems to me, some way of ascertaining, with more or less approximation or definiteness, the amount of oil which is necessary to produce that result.

MR. WILLIAMS: The patent gives us a measure. The measure given can be applied over and over again in the mill. You must reduce below the proportions that will give you the Cattermole effect. The specification says: We have found that reducing the oil below that of the Cattermole process we get this new result. And it is in the record that in the mill, if you increase the oil, immediately you have the appearance of the Cattermole operation, you immediately find in your tailings Cattermole granules or flocks of metal that have not quite formed granules. As Mr. Atwater said, increase the oil and your plant commences to Cattermole. And that everywhere in the mill, is a sure indication that you are departing from our invention.

THE COURT: You contend that when you get below Cattermole you enter upon your domain?

MR. WILLIAMS: Yes. And that is but a repetition

of the exact experiments which took place at the discovery of the invention. That thing can be repeated over and over again. Adjust your plant properly for the agitation air froth, add a little more oil, and you at once go toward the Cattermole conditions, you are departing from the invention; reduce the oil and you come back again. Over and over again that can be done.

(Pages 294-295):

The experiments made at the discovery tell that story. As the oil was reduced step by step, not gradually, but suddenly, this float came to the surface. Mr. Higgins said the float vastly increased upon a reduction to about .3 per cent., and then when he went down to .1 per cent., again, by contrast with what had gone before, the float vastly increased, and in his examination, which was, of course, cross-examination by defendants' counsel, an effort was made to lead him to say that there was a gradual change, and he said no, that it was a sudden change. Suddenly this black froth came up. (Printed Rec., p. 215, Qs. 67-69.)

Now, adjust the plant to produce this froth, then change your conditions and add a little oil, and back you go to Cattermole. Nobody else went below Cattermole. Cattermole is the line of demarcation between what anyone else did and what we did in the first patent in suit.

(Pages 296-297):

The Court: Will you pardon me just at this point? I want to get your idea right there. You say the change is a very sudden one, that you began, and suddenly you noticed a radical change. That is right, is it?

Mr. Williams: That is right.

THE COURT: And you say there was no slow gradation?

MR. WILLIAMS: No, no slow gradation at all.

THE COURT: But a sudden change. If you reduce the oil below a certain limit which is not named, then you get the result which you claim, just exactly as if a see-saw were just about balanced, and you put a pound weight on the other end, and that end would go down.

MR. WILLIAMS: Yes, your Honor.

THE COURT: Just as marked as that?

MR. WILLIAMS: It is as marked as that, and the evidence establishes that.